Intergovernmental Oceanographic Commission　　　　**World Meteorological Organization**
(of UNESCO)

DATA BUOY CO-OPERATION PANEL

GUIDE TO DATA COLLECTION AND LOCATION SERVICES USING SERVICE ARGOS

DBCP Technical Document No. 3

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NOTE

C O N T E N T S

PREFACE

Data buoys are now generally accepted as a very cost-effective means for obtaining meteorological and oceanographic data from remote ocean areas. As such, they form an essential component of marine observing systems established as part of the World Weather Watch, the World Climate Research Programme, the Global Ocean Observing System, the Global Climate Observing System, the Integrated Global Ocean Services System and other meteorological and oceanographic operational and research programmes. The Drifting Buoy Co-operation Panel (DBCP) was set up in 1985 by the World Meteorological Organization and the Intergovernmental Oceanographic Commission. It is a mechanism for coordination and co-operation in the implementation of drifting buoy deployment programmes and a forum for discussing technical problems related to buoy operations. At its 8th session in Paris, October 1992, the DBCP decided to change its terms of reference to include all ocean data buoys on the high seas. Hence its name was changed to Data Buoy Co-operation Panel. The DBCP employs a full-time Technical Co-ordinator, presently based at CLS in Toulouse (France), to provide appropriate technical support.

The utilization of data buoys and many other remotely-located environmental observation systems depends critically on the data collection and location services provided by the Argos system. This system, which is flown on the NOAA (USA) Polar-orbiting Operational Environmental Satellites (POES) and operated by CLS and Service Argos Inc., functions through the Argos Global Processing Centres in France and the USA, as well as through Local User Terminals (LUTs) in a number of countries.

As many WMO and IOC Member countries developed data buoy and other observational programmes using the Argos system, information had to be widely available. Consequently, and at the specific request of the second meeting on the Argos Joint Tariff Agreement, a Guide to Data Collection and Location Services Using Service Argos was prepared and published by WMO in 1983 as Report No. 10 in the series Marine Meteorology and Related Oceanographic Activities.

This report proved to be a remarkably useful and popular reference document for national Meteorological Services and all other users of the Argos system, and it was extensively revised and reprinted as a second edition in 1988. The ninth session of the DBCP, in 1993, recognized that a number of technical and procedural changes which had taken place since 1988 rendered large parts of the guide once more out of date. It therefore requested that it once again be fully revised, reprinted as a third edition, and distributed widely within the existing and potential Argos system user community.

The 1988 revised edition of the Guide to Data Collection and Location Services Using Service Argos was prepared by Dr. Glen Hamilton (USA), with substantial input being provided by the Technical Co-ordinator for the DBCP, Mr. David Meldrum, and by the staff of CLS in Toulouse.

The present 1995 revised edition of the guide was prepared by the Technical Coordinator of the DBCP, Mr. Etienne Charpentier, and by the staff of CLS in Toulouse with some input by Mr. Eric Meindl (USA).Their work is gratefully acknowledged and the thanks of WMO and IOC are extended to them for their time and efforts in support of this very valuable publication. The 1995 edition is basically to reflect recent improvements both in the Argos system and in the GTS data processing sub-system.

1 - INTRODUCTION

1.1 - Purpose of Argos

The Argos system locates fixed and mobile platforms and collects environmental data from them. The system was developed under a co-operative programme between the French Space Agency (CNES, France), the National Aeronautics and Space Administration (NASA, USA) and the National Oceanic and Atmospheric Administration (NOAA, USA). The purpose is to provide an operational service for the entire duration of the Polar-orbiting Operational Environmental Satellites (POES) NOAA programme (TIROS-N series), that is, beyond year 2000.

System exploitation is the responsibility of Collecte Localisation Satellites (CLS), established in early 1986 as a subsidiary of CNES and the French oceanographic institute IFREMER. CLS operates the French Global Processing Centre (FRGPC) in Toulouse and handles all user relations outside North America. The American subsidiary of CLS, Service Argos Inc., handles Argos data processing at the US Global Processing Center (USGPC) in Landover, MD, and caters for all United States and Canadian users. New programmes using the Argos system must be formally approved by the joint CNES/NASA/NOAA Argos Operations Committee. The technical characteristics of the Argos system are detailed in Chapter 3. The administrative procedures to follow for using Argos are described in Chapter 9.

The Argos system comprises:

- A set of user platforms, fixed or mobile, deployed at sea, on land or in the air and transmitting independently. The platform is the carrier complete with its sensors and Argos Platform Transmitter Terminal (PTT),

- A desired complement of two operational NOAA spacecraft and two in backup in simultaneous orbit, with instrument packages that receive PTT messages on a random access basis, then separate, time-code, format and retransmit the data to ground stations,

- The ground stations and two Global Processing Centres (GPCs) in Toulouse, France and Landover, MD, USA, where data are retrieved, processed, and distributed to users. Each centre can take on the full operational workload if the other fails.

1.2 - Argos for meteorology and oceanography

Argos has demonstrated its great potential for the collection of much needed observations from data sparse oceanic areas. Data collection platforms that utilize the Argos system for meteorological and oceanographic purposes can be categorized into three groups:

(a) Moving platforms: drifting buoys, ships and ice buoys;

(b) Fixed platforms: moored buoys and automatic weather stations;

(c) Sub-surface floats.

Although drifting buoy technology was applied to oceanographic and meteorological problems prior to 1975, the launch of the NIMBUS satellite and, from 1978, the TIROS-N series satellites carrying the Argos system started an explosion of drifting buoy technology and applications in support of operational services and scientific experiments.

The First GARP Global Experiment (FGGE) in the late 1970s was the first occasion to demonstrate the effectiveness of the Argos system for the global collection of meteorological data from drifting buoys. More than 300 drifters from Member countries were deployed in the southern hemisphere during the FGGE period. Sea-surface temperature and atmospheric pressure data from the buoys were collected by Argos and sent over the WMO Global Telecommunication System (GTS) four times a day (see reference 1). The lifetime of the buoys proved to be longer than expected, some buoys transmitting valid data for over a year.

Meteorological services then extensively deployed FGGE type meteorological buoys to measure atmospheric pressure, air temperature, and sea surface temperature. Some of the buoys are now equipped with reliable wind speed and wind direction sensors. Technology has improved and the lifetime increased. Data are routinely distributed onto the GTS.

Drifting buoys have a long history of use in oceanography, principally for the measurement of currents by following the motions of floats attached to some form of sea anchor or drogue. Since 1988, over 1500 Lagrangian drifters have been deployed in the world oceans in the Surface Velocity Program (SVP) of the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean and Global Atmosphere Program (TOGA). These buoys were standardized in 1991, with small spherical hull and floats, and large Holey-Sock drogue centred at 15 meters below the surface. They are very reliable, with half lifetimes greater than 450 days (with drogue still attached).

In 1993, Lagrangian Drifters with barometer ports were tested in the high seas (more than 20 prototypes) and proven reliable. The Lagrangian Barometer Drifter, designed at the Scripps Institution of Oceanography for WOCE, is now commercially available at low cost, and meets both oceanographic requirements (research: measurements of sea surface currents) and meteorological requirements (operational: air pressure).

Until 1 November 1991, the WMO code used for GTS distribution of drifting buoy data was FM 14-VII DRIBU. It was then replaced by FM 18-IX Ext. DRIFTER until 2 November 1994. Since then, the formal WMO code used for drifting buoys has been FM 18-X BUOY.

Since 1986, sub-surface temperature profiles measured by eXpendable BathyThermographs (XBTs) on board Voluntary Observing Ships (VOSs) have been

transmitted through dedicated Argos terminals then transferred onto the GTS using the code form FM 63-X Ext. BATHY.

Ice buoys have been used extensively in Arctic and Antarctic regions to track ice movement and are available commercially for deployment by ships or aircraft. Such buoys are equipped with low temperature electronics and lithium batteries that can operate at temperatures down to -50°C. In addition to the regularly-computed Argos locations the ice buoys can be equipped with satellite navigation receivers (e.g. Global Positioning System (GPS)) which can compute even more accurate positions for transmission through the Argos system.

In 1991, an International Arctic Buoy Program (IABP) was established with the primary goal of maintaining an optimal array of ice buoys capable of measuring basic meteorological variables in the region for both operational and research purposes. In 1994, a World Climate Research Program (WCRP) International Program for Antarctic Buoys (IPAB) was created with similar goals in the Antarctic Sea Ice zone.

The formal WMO code used for ice buoys is now FM 18-X BUOY.

Moored buoys are normally relatively large and expensive platforms. If a moored buoy sustains a mooring failure it represents a potential loss of costly equipment and a possible hazard to navigation. For these reasons the Argos system has been used for location determination for moored buoys. In addition, some Member countries use the Argos system for normal transmission of meteorological observations from moored buoys.

The Tropical Atmosphere Ocean (TAO) array of ATLAS Moorings: About every four to seven years there is a significant disruption of the atmospheric and oceanographic circulation patterns in the equatorial Pacific. These changes have complex effects on global scale weather. The disruption's two components, El Niño and its atmospheric component, the Southern Oscillation, are the focus of the international Tropical Ocean and Global Atmosphere (TOGA) program. Through an ambitious program in the equatorial Pacific, TOGA is investigating the oceanic and atmospheric dynamics relating to the El Niño/Southern Oscillation phenomenon and its importance in the year to year variability of global climate. As part of the TOGA program, efforts have been made to enhance the real-time ocean observing system in the tropical Pacific Ocean. One element of this improved system is the TOGA Tropical Atmosphere Ocean (TAO) array of Autonomous Temperature Line Aquisition System (ATLAS) moorings. The ATLAS mooring, developed at NOAA's Pacific Marine Environmental Laboratory (PMEL) Seattle, WA, in the 1980's, is a taut wire surface mooring with a toroidal float. It is deployed in depths of up to 6000 meters. Measurements from the mooring include surface variables (wind, air and sea surface temperature), as well as subsurface temperatures down to a depth of 500 meters. These data are transmitted to shore in real time using Argos, processed by CLS or Service Argos Inc., and placed on the GTS. Post recovery processing and analysis of the data is performed at PMEL. This array and its planned expansion is the result of international collaboration between scientists from France, Japan, Korea and the USA. The first ATLAS mooring was deployed in December 1984. In 1994 over 50 ATLAS moorings were operational in the equatorial Pacific Ocean.

The WMO code used for GTS distribution from Service Argos of moored buoy data is now FM 18-X BUOY (as for drifting buoys).

Automatic Weather Stations (AWS) are currently used in remote areas such as Greenland and Antarctica to collect meteorological data.

In addition, some automatic land stations which normally report data via geostationary satellite are equipped with back up Argos reporting systems in the event that the primary system fails.

The WMO code used for GTS distribution of AWS data from Service Argos is FM 12-X SYNOP.

Sub-surface floats are autonomous free-drifting platforms gathering data at mid-depth and surfacing from time to time to transmit via Argos. Argos both locates the float at the surface and collects the data stored in their memory. The two main floats are ALACE (Autonomous Lagrangian Circulation Explorer) and RAFOS (SOFAR (SOund Fixing And Ranging) spelled backwards since RAFOS is the reverse concept of SOFAR where signals are emitted from the float and then reveived at moored buoy sites for location computation; SOFAR floats are no longer used).

ALACEs are autonomous floats that are repeatedly located when they pop up to the surface for satellite location through the Argos system. While they are at the surface their drift gives a measurement of the surface current. The cycling time is adjustable. The instrument is designed for 50 cycles. The basic cycling time used is 36 days, to provide a five-year lifetime.

RAFOS floats are drifting listening stations that record the time of arrival of acoustic signals from moored sound sources and at the end of their lives pop up to report the recorded data through Argos. Present recording lifetimes are roughly 2.5 years. The recently-developed MARVOR (word for sea horse in Breton) floats work on the same principle as RAFOS. In addition, they can pop up and down several times during their lifetime and transmit data collected each time they surface.

Sub-surface floats are used in the World Ocean Circulation Experiment (WOCE) to measure the global distribution of current velocity below the high eddy noise region near the surface, to provide an accurate mean velocity. The mean velocity is combined with hydrographic data to compute water mass transport in the major ocean basins. The WOCE goal is to compute a five year mean velocity on a 500 x 500 km2 scale. The requirements translate into the following number of five-year lifetime floats in the oceans: Atlantic: 225, Indian: 180, Pacific: 495, Southern (south of 45°S): 114.

Sub-surface float data are not disseminated onto the GTS principally because the data are not available in real time.

1.3 - Geophysical variables

The variables measured at a data buoy station include one or more of the following elements:

- Atmospheric pressure,
- Atmospheric pressure tendency,
- Wind speed,
- Wind direction,
- Air temperature,
- Sea-surface temperature,
- Sub-surface temperatures,
- Sea surface salinity,
- Sub-surface salinity,
- Wave period and height.

NOTE: Since the location of the drifting buoy is also determined in Argos processing, sea surface currents can be derived provided that the buoy is a drogued lagrangian drifter.

Environmental observations required to support meteorological and oceanographic services and research are discussed in relevant WMO and IOC publications (see references 2, 3, 4 and 5). In these publications the relative priority of importance of measuring individual parameters is shown to depend to some extent on the type of user of the data. Clearly, however, atmospheric pressure and wind speed and direction are of utmost importance to weather analysis and forecasting and are complementary to each other. Sea-Surface Temperature (SST) is also of importance for weather analysis and forecasting and highly critical for fisheries, satellite temperature retrievals, climate studies, and other areas. SST data from drifting buoys are increasingly being used as ground truth measurements for remote sensing applications. Air temperature is important for air/sea interaction and climate programmes. Observations of waves are important for all types of marine users. Current drift and sub-surface temperatures have important oceanographic applications.

Measurements of surface (sea level) atmospheric pressure and SST have been routinely made by drifting buoys and are considered operationally proven. Winds are being measured on drifting buoys of some countries and are now considered reliable. Atmospheric pressure, SST, and wind data from buoys are therefore routinely inserted in numerical weather prediction models. Air temperature measurements on drifting buoys can be useful for operational purposes, although the measurements are often made very close to the sea surface. Measurement of waves from drifting buoys is in the development stage and should be pursued. Measurement of sub-surface temperatures has been proven feasible and has become operational.

Interpreting buoy tracks used to be difficult. The lack of understanding regarding the effects of wind stress on drifting buoys and the currents of the uppermost few meters of water initially made many oceanographers cautious about directly relating buoy motions to ocean currents. Drogues substantially enhanced the ability of drifting buoys to represent ocean currents. Recent Lagrangian drifters with high drag area ratios (e.g. >40) such as those developed for the WOCE/TOGA Surface Velocity Program (SVP)

now measure sea surface currents with an accuracy of 2 cm/s. Using a correction formula, a wind correction will improve that accuracy to 1 cm/s if the wind is known to within 4 m/s. In addition, drogue lifetimes have been considerably increased. For example, Standard SVP Lagrangian Drifters equipped with Holey Sock drogues proved to have half lifetimes greater than 450 days with drogues still attached.

In addition, drogues on drifting buoys are important for weather analysis and forecasting as they allow a longer residence time and reduce replacement costs.

1.4 - Requirements for international coordination

Before 1985, several countries had small-scale drifting buoy programmes underway to provide data from oceans in their area of concern for regional improvement in weather analysis and forecasting and research purposes. As national programmes have evolved and become operational, enhanced international coordination has been required to maximize the global impact of these national/international resources.

To this end, the thirty-seventh session (Geneva, June 1985) of the WMO Executive Council approved the establishment of a Drifting Buoy Co-operation Panel (DBCP) and supported the proposal that the panel be served by a Technical Co-ordinator. At its nineteenth session (Paris, March 1986), the IOC Executive Council agreed to co-sponsor the panel. The terms of reference for the panel and its Technical Coordinator are given in Annex I.

At its first session (Toulouse, October 1985), the DBCP established its operating procedures and defined its work plan and objectives for the first year. In its second session (Geneva, October 1986), the DBCP organized the recruitment of the Technical Co-ordinator and established the financial and administrative procedures relative to that matter. It also defined his tasks and work plan for the coming year. The Technical Co-ordinator was finally appointed in June 1987 and hosted by CLS in Toulouse.

At its eighth session in Paris, October 1992, the DBCP decided to change its terms of references to include all ocean data buoys on the high seas. Hence its name was changed to Data Buoy Cooperation Panel. The DBCP acronym remains unchanged.

Panel sessions are organized in turn by WMO and IOC, and are held annually, normally in conjunction with the Argos Joint Tariff Agreement meetings in October or November (see Section 9.4) The panel itself is composed of representatives of Members of WMO and Member States of IOC. Observers from any organization or programme interested in the deployment of data buoys or the use of data buoy data are welcome at panel sessions.

The need for meteorological and oceanographic data from marine areas continues to increase. Many Members conduct programmes with buoys but not all buoy data are introduced into the GTS. It is extremely important that these data be made available to the worldwide community via the GTS. Solving this problem has been a primary goal of

the Technical Coordinator of the DBCP, and results since the position was created have been very successful.

Difficulties with drifting buoys include liability, legal status, access to data and recovery and repatriation of buoys. More buoys means a greater likelihood of collisions with ships and other marine traffic, resulting in damage to both. It would probably be helpful to obtain information as to what size or mass a buoy must have to be considered a hazard to navigation. During FGGE, the WMO distributed a pamphlet on FGGE buoys and their purpose. The pamphlet included a request to report their position, if sighted, thus adding a positive aspect to a buoy sighting. The questions of salvage rights, awards, marking and safety need to be examined and, to this end, the IOC has initiated a study of the legal status of all Ocean Data Acquisition Systems (ODAS), including drifting buoys.

Problems have been experienced with regard to drifters that enter waters under jurisdiction other than that of their country of origin. Repatriation of buoys drifting ashore or recovered by a foreign country is also a problem in the operational use of drifting buoys.

Sometimes buoys drift out of the area of interest of their original deployer. According to present procedures, a buoy drifting into another WMO region still retains the initial WMO-allocated buoy identification number (see Annex II). It is therefore important that the identifier numbers actually used by deployers be registered with WMO and circulated to all Members in the monthly letter on the Operation of the World Weather Watch (WWW) and Marine Meteorological Services (MMS).

To increase the quantity and quality of buoy data disseminated on GTS without interfering with Principal Investigators' (PI) requirements, the DBCP initiated the development of a new flexible GTS sub-system. The system (partly funded by voluntary contributions from DBCP members) was implemented at both Argos Global Processing Centres: Toulouse, France, and Landover, MD, USA. Work began in July 1991 and the new system was implemented operationally in two phases: phase 1 in January 1993, and phase 2 in September 1993. To achieve the goals, many technical obstacles that prevented certain platforms from being distributed on GTS have been overcome (e.g. sensors no longer have to be placed in a specific order in the Argos message). New sensor data processing, quality control, and encoding options are now also available.

For buoy data distributed on the GTS, the DBCP addressed the issue of delayed time Quality Control (QC) and implemented Quality Control Guidelines in January 1992. It set up an electronic bulletin board (BUOY.QC on Omnet) for exchanging quality information on buoy data. Numerous Principal Meteorological or Oceanographic Centres (PMOC) responsible for quality control of GTS buoy data report questionable data via the bulletin board. The DBCP Technical Coordinator is typically the focus for ensuring data problems are resolved; he also coordinates back-up for this activity among the participating centres. In December 1994, following the termination of the Omnet system, the QC system communications were transferred to Internet.

Co-operation between the meteorological and oceanographic communities is also an important factor for the promotion of drifting buoy programmes. Meteorologists' and

oceanographers' requirements are not mutually exclusive, and they have much to gain by co-operation. Buoys deployed primarily for oceanographic purposes may contribute useful meteorological data if equipped with suitable sensors, and meteorological buoys may similarly provide oceanographic data. Hardware developments aimed at one application may be beneficial to the other. One community may be able to assist the other in the testing, deployment or tracking of buoys. This might take place on a local, national, regional or global scale. The DBCP is actively involved in such coordination matters, among many other tasks. At its third session (Paris, October 1987) the DBCP adopted a recommendation urging greater co-operation between meteorologists and oceanographers in buoy instrumentation and deployments (see reference 6). Since then, cooperation between the two communities has increased steadily. A fair number of regular meteorological buoys have been equipped with thermistor strings. In addition, the SVP Global Drifter Center (GDC), operating from the Scripps Institution of Oceanography (USA), designed a new low cost barometer drifter. In 1993 and 1994, under joint SVP/DBCP sponsorship, and in cooperation between the GDC and meteorological services from Australia, Canada, France, and the United Kingdom, more than 20 prototypes were deployed in the high sea and evaluated in an operational environment. The deployments demonstrated that the device could reliably meet both the meteorological and oceanographic communities' requirements since it can accurately measure sea surface currents, sea surface temperature, and atmospheric pressure.

2 -   DRIFTING BUOY HARDWARE

As sensor platforms, drifting buoys have proven advantages for use in data-sparse ocean regions. Their small size makes deployment easy and inexpensive and allows for launching from aircraft or ships. The basic hull, sensor, and electronics configuration are simple and reliable and satisfactory performance has been obtained (following thorough design studies and testing) in severe ocean climates. The buoys are expendable, thereby avoiding the high expense of recovery, maintenance and refurbishing. A full description of drifting buoy hardware, as well as all other aspects of drifting buoys, is given in reference 7.

2.1 - Buoy hulls

Buoy hull design depends mainly on the application. For real-time marine meteorological data acquisition it is important that the antenna be maintained above the water for optimum telemetry to the satellite. For this reason, most FGGE buoy hulls were of a simple spar and flotation collar configuration. Other design criteria include a low profile to minimize wind drag and low hull surface drag so the buoy can be used in a drogued configuration with minimal surface current effects. In the case of the SVP drifter the surface float is often submerged due to drag from the large current following drogue. Despite this undesirable feature, reliable communication is achieved and , with the recently developed SVP-barometer (SVP-B) drifter, surface atmospheric pressure measurements are possible. Buoy hulls are commonly constructed of a fibreglass or aluminium shell with a polyurethane filler to maintain buoyancy if the shell is penetrated. Power supplies have traditionally been provided by alkaline, manganese or lithium batteries.

An important outcome of drifting buoy technology programmes has been the development of computer time-domain models to aid in the design of drifting buoy systems. With the model, the motions of a buoy hull can be simulated and the critical engineering parameters needed for design synthesis can be determined. The model can be used to predict the capability of a drifting buoy to measure the velocity of a parcel of water in which the buoy is embedded. The model can also be used to predict motions of buoys and forces within the buoy-tether-line-drogue system.

2.2 - Sensors

For buoys to contribute useful data to the Global Observing System (GOS) of the World Weather Watch (WWW) of WMO, and to the World Climate Research Programme (WCRP), basic accuracy requirements relating to pressure, temperature and wind measurement should be met. Some of the requirements expressed in the WWW long-term plan for 1996 to 2005 (see reference 4), are shown in Table 1.

Table 1 - Basic WWW Requirements.

Physical parameter	Approximate range	Observational error (RMS)	Frequency of observations	Horizontal resolution
Surface atmospheric pressure	800 to 1050 hPa	0.2 to 1 hPa	1 to 24/day	≤250 km
Surface air temperature	-50°C to 45°C	0.5°C	1 to 24/day	≤250 km
Surface wind vector	0 to 40 ms^{-1}	1 to 2 ms^{-1}	1 to 24/day	≤250 km
Sea surface temperature	- 2°C to 35°C	0.5°C (ship) 0.2°C (buoy)	≤4/day	250 km

The observational error (RMS) specified is linked to the total system accuracy of the buoy measurement system. The measurement accuracy should be maintained under the environmental operating conditions and lifetime of the system deployed. The individual contributor should allocate individual system component error sources to achieve the required system accuracy.

Data processing at the Argos Global Processing Centres does not presently include procedures for averaging data received from buoys. Sensor data processing on the buoys is therefore required. The physical parameters measured by the buoy system need to be averaged to minimize errors resulting from buoy motion and environmental variability. The desirable goal is at least a one-minute average on the atmospheric pressure and surface water temperature measurement. If digital averaging techniques are used, a minimum of ten data samples should be used to obtain the average during the measurement period.

It is important to note that, at present, the Argos software requires verification in the form of at least two identical sensor values (not necessarily consecutive; in addition, whole Argos messages don't have to be identical) from a PTT during a satellite overpass before those observations will be put on the GTS (unless other techniques such as checksums are used). This is conveniently achieved by averaging the sensor data for a few minutes prior to transmission.

Atmospheric Pressure: measuring representative atmospheric pressure from a small drifting buoy in the open ocean is difficult. Error sources include: natural atmospheric pressure variation, wind interaction with the sensor, sensor error, data quantisation, sensor calibration and long-term drift, telemetry bit errors and the on-board selection of a measurement value characteristic of all values produced by the sensor during a particular time interval. Cost is also a significant consideration. Pressure sensors with inherently good long-term stability characteristics and good repeatability are expensive; however recent engineering advances have driven down the cost of barometers significantly. The limited power available on a small drifting buoy puts further constraints on the required operational characteristics of the sensor. Pressure measurement devices that have been employed are aneroid cells, beam balance quartz crystal transducers, and piezo-resistive transducers. An important component of the measurement system, with regard to wind error, is the inlet or pressure port which allows the ambient pressure to be transmitted freely into the sensing element. The error or pressure change is related to the shape and configuration of the inlet and, for most configurations, the pressure error is related to the square of the wind velocity. Various schemes have been devised to correct for this problem. Some pressure port designs have been tested in wind tunnels. During buoy developmental programmes problems have been encountered with water leakage through watertight seals and into barometer vents; water traps and drains and design changes were needed.

Air Pressure Tendency can be derived from latest and recorded Atmospheric Pressure measurements made at an interval of 3 hours. Computation is done onboard the buoy. Characteristics of the pressure tendency can also be computed and transmitted by the buoy.

Wind: Several countries have conducted development programmes in wind measurement from drifting buoys and various methods have been used. One approach is to measure the drag force on a sphere which is proportional to wind speed. The most conventional method is to use cup or vane anemometers. The measurement of wind direction has concentrated on using a vane to point the buoy into the wind and use a compass to compute direction. The Argos GTS sub-system is capable of making an automatic geo-magnetic variation correction (using the 1985 World Chart Model) on wind direction data to compensate for the bias due to the difference between true North and magnetic North. This correction depends on the buoy location and time of observation.

Air Temperature: Results of developmental tests have shown that air temperature can be measured satisfactorily using thermistors. A source of error is the heating effect produced when solar and infrared radiation strike the air temperature transducer. Various methods of constructing radiation shields have been devised.

Sea Surface Temperature (SST) measurements have routinely been provided by thermistors or resistance thermometers and reported temperature values have normally been within system specifications.

Sub-surface Temperature measurements have been successfully conducted from drifting buoys to a depth of 600 m. Difficulties during deployment have brought to light the need for a self-contained deployment mechanism for these systems. Various cable

designs have been tested and failure modes for sensors, wires and cables have been investigated.

Sea Surface Salinity (SSS) sensors are now being developed and tested on Lagrangian drifters.

2.3 - Drogues

Confidence in the ability of drifting buoys to represent ocean currents is greatly enhanced by the addition of a sea anchor or drogue to increase the cross-sectional area of the buoy system at the depth at which the currents are to be measured. The most widely used form of drogue is now Holey-Sock drogues (a vertical cylinder made of fabric with open hoops at the end). TRISTAR (large semi-rigid, three axis symmetric drogue in the shape of a corner-radar reflector) designs are still being used. Older designs were parachute and window-blind drogues. Many other types of drogues are possible, e.g. various shapes made of rigid material and long lengths of rope weighted at the free end. Thermistor strings used to measure sub-surface temperature tend to act as drogues.

Buoy drift is due to the combination of wind drag and drag from the motion of the buoy, drogue and drogue line with respect to the water. In the simplest case, where the drogue is in the surface mixed layer, the current sensed by the buoy and by the drogue may be assumed to be the same. When the drogue is at a depth where the current is significantly different from that in the upper mixed layer the situation becomes much more complex. Differences in direction between the currents in the surface layer and those at the drogue depth may also lead to large errors in the apparent current at drogue depth.

The most critical problem with drogues is separation from the buoy before the end of its operational life. In many cases it is not possible to unambiguously detect where in the buoy trajectory the drogue was lost. Several principles have been used in attempting to design a sensor which will indicate whether the drogue is still attached. The latest design records the portion of the time the buoy is submerged. In high seas, drifters with drogue detached are rarely submerged.

An important factor in drogue design for sea surface currents measurements is the drag area ratio. The drag area ratio is the drag coefficient of the drogue times the frontal area divided by the sum of the products of the drag coefficient and the largest projected frontal areas of floats and tethers.

Normally drag area ratios larger than 40 are required for obtaining computed sea surface current accurate to 2 cm/s. For calibrated drifters a wind correction formula can improve that accuracy to 1 cm/s provided the wind field is known to within 4 m/s. See reference number 11 for details.

3 - THE ARGOS DATA COLLECTION AND LOCATION SYSTEM

3.1 - Argos Platform Transmitter Terminals

Any platform used in conjunction with the Argos system carries an electronic transmitter termed a Platform Transmitter Terminal (PTT). A PTT includes an antenna, an RF modulator and power amplifier, message generation logic, a sensor interface unit, an ultra-stable oscillator and a power supply. Argos PTTs must meet certain technical specifications and be approved by CLS/Service Argos.

<u>Radio frequency specifications</u>

(a) Transmission frequency: All PTTs transmit on the same frequency band, from 401.646 to 401.654 MHz. According to the ITU Radio Regulations this frequency falls in the 401-402 MHz band allocated to the Meteorological Aids Space Operation (space-to-earth). However it is understood that the PTT operator must obtain authority from his appropriate national authorities to transmit on this frequency.

From the new-generation NOAA-K, scheduled for launch in 1996, PTTs will be assigned to channels within the 401.620 to 401.680 MHz band.

(b) Transmission sequence: Each PTT transmits at regular intervals. The period currently ranges from 90 to 120 seconds for platforms to be located, and is usually 200 seconds for data-collection-only type platforms depending on the type of application and the latitude of the PTT. For a given PTT the repetition period is fixed as allocated by Service Argos and must not be changed without authorization. The duration of a single transmission burst depends on the data message length but is always less than one second (360 to 920 milliseconds).

(c) Radiated power: The peak radiated power is less than 5 W which allows the use of low-power electrical sources like dry cells, batteries and even solar cells. Each PTT must also be equipped with a safety system which automatically switches off the PTT if it transmits continuously for more than one second.

(d) Modulation technique: The carrier is biphase-L-modulated by a 400 Hz PCM signal.

<u>Message format</u>

The transmitted message consists of the following contiguous elements:

(a) Unmodulated carrier for 160 milliseconds, to permit the Argos onboard receiver to lock onto the carrier.

(b) A 15-bit preamble to permit the Argos onboard equipment to lock onto the bit rate.

(c) An 8-bit code synchronization word followed by one spare bit and 4 bits giving the length of the sensor data (number of 32-bit blocks).

(d) The PTT identification code, as assigned by Service Argos and coded over 14 or 15 bits, followed by 5 or 6 error checking bits: the first 16,000 PTT IDs were encoded over 14 bits, and a set of 32,000 was started in 1994 using 15 bits.

(e) Sensor data: 32 and 256 bits in 32-bit steps. The encoding and format must comply with the rules described in Section 4.1.

The message format is detailed hereafter. The message duration may vary between 360 ms for a 32-bit message and 920 ms for a 256-bit message.

Table 2 - Argos Message Format

Unmodulated carrier (160 ms)	Modulated carrier A B C D E F
Minimum 360 milliseconds	Maximum 920 milliseconds
A Bit sync	15 "1" bits
B Frame sync	8 bits 00010111
C Initialization	1 "1" bit
D Sensor number	4 bits
E Identification and error checking	20 bits
F Sensor data	32 to 256 bits (by steps of 32)

Oscillator stability

The definition of PTT oscillator stability is frequency error divided by nominal carrier frequency ($\Delta f/f$) and is characterised and evaluated as short-term, medium-term and long-term stability.

Short-term stability: stability during the time to transmit a single message (normally between 360 and 920 milliseconds). The specification is in terms of a period of 100 milliseconds. If short-term stability is worse than 10^{-8}, the message will not be acquired

by the Data Collection and Location System (DCLS), i.e. no data will be collected. For location-type PTTs, the stability must be better than 10^{-9}; otherwise sensor data can be collected but location accuracy is poor.

Medium-term stability: stability during a 10- to 15-minute satellite pass over a PTT, i.e. oscillator frequency drift. The results of simulated trials are summarized in Table 3 below. The table gives the theoretical effect on location accuracy due to oscillator frequency drift during the satellite pass.

Table 3 - Location accuracy as a function of medium-term stability

	Medium-term stability	Location accuracy
$\Delta f/f$	Hz/min	meters
2×10^{-9}	0.04	<100
5×10^{-9}	0.10	200
10^{-8}	0.20	400
2×10^{-8}	0.40	1,000
5×10^{-8}	1.00	2,000
10^{-7}	2.00	4,000
2×10^{-7}	4.00	10,000
$>2 \times 10^{-7}$		calculation aborts

Numerous tests show that the prime cause of poor medium-term stability is temperature variation during the satellite pass. The choice of oscillator thus depends on the location accuracy sought and on the platform environment. The temperature within, say, a buoy floating on the ocean surface is likely to be virtually constant. Thus, in such an application, a standard quality oscillator will almost certainly offer sufficient medium-term stability. Ultra-stable oscillators capable of accommodating steep temperature gradients are very expensive and often require large amounts of power for internal temperature regulation. In many cases, the required medium-term stability can be achieved using a standard oscillator inside a carefully insulated housing. Often this housing will take the form of a polystyrene or polyurethane box with a wall thickness of approximately 7 cm.

Long term stability: stability during the period separating successive satellite passes, i.e. 100 minutes. If the previous transmission was received less than 12 hours before, a difference of more than 0.24 Hz/min is considered unacceptable. After 12 hours without reception, the long-term instability is automatically compensated by the location processing if it does not exceed 10^{-6}. However, if the long-term instability corresponds to a steady drift in the transmission frequency, then the operating limit will be determined by a ±4000 Hz tolerance. This has to be so since this tolerance was determined in accordance with the bandwidth specified for the onboard DCLS. The

tolerance of ±4000 Hz can be broken down between the manufacturing tolerance and the ageing tolerance which depends on the PTT lifetime.

PTT certification

To be compatible with the Argos onboard equipment, and avoid interfering with other PTTs, each PTT design must be approved by CNES. For a newly-designed PTT the approval is based both on design analysis and on type certification tests. The type certification is requested by the PTT manufacturer and performed under CNES supervision in Toulouse (France). The manufacturer receives a type-certificate once his PTT has successfully passed the certification test. Once a PTT design has been type-certified, PTTs manufactured with the same design do not need further certification tests. All these production models must carry a label giving the type, the serial number and indicating that the type has been certified by CLS/Service Argos. If any modification or design changes are made to the certified design it will be necessary to re-submit a prototype for testing and re-certification. A list of manufacturers supplying Argos-certified PTTs is available from Service Argos. For any new manufacturer intending to manufacture a newly-designed PTT, the detailed certification specifications must be requested from Service Argos.

3.2 - Argos space segment

The space segment of the Argos system typically consists on June 1995 of two NOAA satellites, plus two in backup, in low earth orbits. Each has an Argos onboard DCLS for PTT message reception, processing and retransmission.

Under a negotiated cooperative agreement with Japan, significant enhancement on the space segment, will occur in 1999, when Argos will fly a two-way instrument on ADEOS II. After the year 2000, a further advanced Argos instrument will be considered for inclusion on NOAA-N' and O, P, Q, and EUMETSAT METOP-1 and 2.

NOAA Polar-orbiting Operational Environmental Satellites (POES)

The satellites carrying the Argos DCLS are the polar-orbiting NOAA TIROS-N series. The first TIROS-N satellite was launched on 13 October 1978. The present NOAA satellites are produced and launched by the National Aeronautics and Space Administration (NASA, USA), using funds from the National Oceanographic and Atmospheric Administration (NOAA, USA). The NOAA satellites are operated by NOAA's National Environmental Satellite, Data, and Information Service (NESDIS).

TIROS-N was a research and development satellite serving as a prototype for the follow-on series. All the following satellites in the series are designated by letter before launch and are numbered consecutively after successful launch. Thus, NOAA-A was numbered NOAA-6, NOAA-C numbered NOAA-7, and so on. The present Advanced

TIROS-N (ATN) programme is an extension of the TIROS-N programme. The first satellite in the ATN series was NOAA-E, numbered NOAA-8.

The system satellites in July 1995 were NOAA-D and NOAA-J.

The main factor determining how many user messages the onboard system can output to Earth for processing at the Argos centres, is called the telemetry rate. The telemetry rate has gradually increased:

- 720 bits/second (b/s) in the late 1970s and 1980s;
- 960 b/s from 1988 with NOAA-H;
- 1200 b/s with NOAA-J, operational in January 1995;
- 2560 b/s with NOAA-K, -L and -M, starting from NOAA-K in 1996.

Under a new optional service introduced in 1994, in addition to the two operational NOAA satellites, Argos programs can be served by an extra satellite (e.g. NOAA-F in July 1995). The main advantage of this three satellite configuration is that users' platform locations and sensor data are updated more often. The results are also spread more evenly during the day.

The satellite coverage is to be enhanced with the launch of other satellites such as ADEOS-II. It is also examined to process data from the other NOAA's standby satellites.

On board the satellites

The TIROS-N satellites comprise three elements (see figure 1):

(a) The Equipment Support Module (ESM), a five-sided box-like structure. Four of the side faces are equal in size and accommodate thermal louvers. The fifth side is wider than the other four and accommodates earth-pointed equipment like communications antennae (including the DCLS antenna);

(b) The Reaction Support Structure (RSS), at one end of the ESM, including the last stage injection motor, an attitude control propulsion system and the boom-mounted solar cell array. The solar array is 11.6 m2 and is motor driven to rotate once per orbit in order to face the sun continually during the daylight portions of the orbit;

(c) The Instrument Mounting Platform (IMP) at the other end of the ESM is a very stable platform carrying the attitude control sensors and the main earth observation instruments. The IMP is stabilized to within 0.2°.
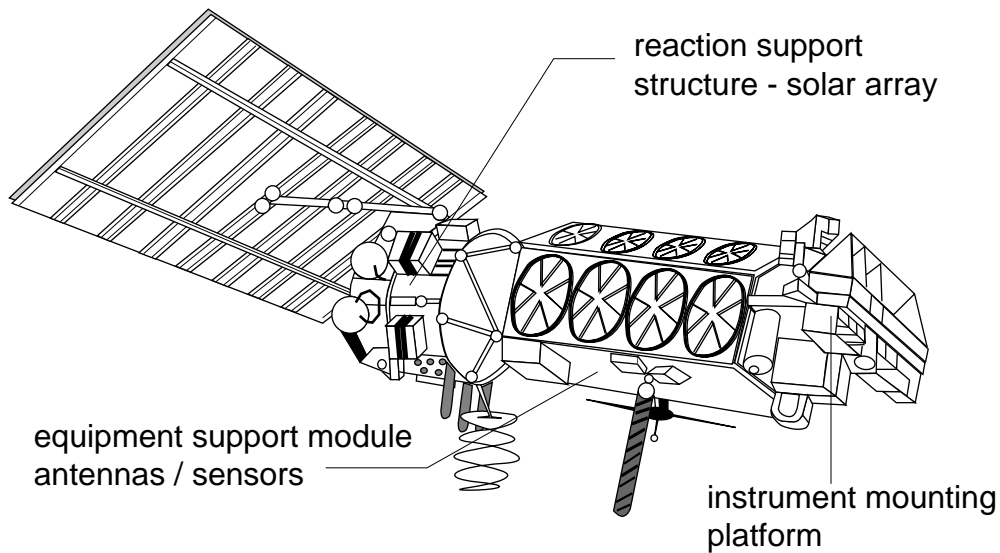
Figure 1 - TIROS-N satellite

NOAA/TIROS-N orbit

Advantages of a near-polar sun-synchronous orbit:

(a) It provides global coverage of the earth, including polar regions.

(b) It maintains the satellite in a relatively constant relationship to the sun, thus permitting satellite passes at approximately the same local time each day.

The nominal orbital parameters of the NOAA satellites are summarized in Table 4 below:

Table 4 - Nominal orbital parameters for the NOAA/TIROS-N satellites

Orbit	Altitude (km)	Inclination (degrees)	Period (minutes)	Revolutions per day	Ascending node local solar time
1	830	98.7	101.3	14.18	19.30
2	870	98.9	102.3	14.07	13.40

Due to launch-related effects, orbit parameter errors may result within the following three-sigma limits:

- altitude: ± 18.5 km
- inclination: ± 0.15°
- apogee/perigee altitude difference: less than 56 km
- ascending node local solar time: ± 15 minutes in two years

The 15-minute ascending node specification during the two-year scheduled lifetime keeps the two satellite orbital planes at a constant angle to each other. Satellite passes over users' platforms are therefore evenly spread through the day.

After injection, external forces (solar pressure, gravity, airdrag) will cause orbit parameter changes.

Argos Data Collection and Location System (DCLS)

The onboard Argos DCLS receivers pick up the messages transmitted by platforms within the satellite coverage. Messages are separated in time through the asynchronization of transmissions and the use of different repetition periods. Messages are separated in frequency as a result of the different Doppler shifts in the carrier frequencies received from the various PTTs. Up to four simultaneous messages (eight after NOAA K) can be acquired by the Argos DCLS, provided they are separated in frequency.

When a message is acquired the DCLS records the time of acquisition, measures the received carrier frequency and demodulates and records the PTT Identification (ID) code and the sensor data. These data are formatted and transmitted to the TIROS Information Processor (TIP).

Beginning with the launch of NOAA-K in 1996, the Argos instrument bandwidth will be increased, and the number of onboard Data Recovery Units (DRU's) will be doubled from four to eight. Doubling the DRU's significantly increases the number of platforms able to be received, and increases the effective data rate.

Also beginning with NOAA-K, Argos will increase the sensitivity of the onboard receiver, thereby reducing the power requirement for transmitters. An increase in sensitivity, coupled with designation of a portion of the wider bandwidth to low power transmitters, will allow very weak signals to be received by the satellite.

From ADEOS-II launch in 1999, a two-way link is added to the DCLS.

Argos 3 DCLS, with enhanced capabilities, will fly from year 2001 starting with METOP I.

Coverage of data collection

At any moment the area on the globe instantaneously seen by one satellite is about 5,200 km in diameter, assuming that the line of sight to the satellite is 5 degrees above the horizon. As the satellite orbits, the ground track of this circle produces a swath 5,200 km in width encompassing the earth (figure 2). At each orbit this swath covers both the north and south poles.
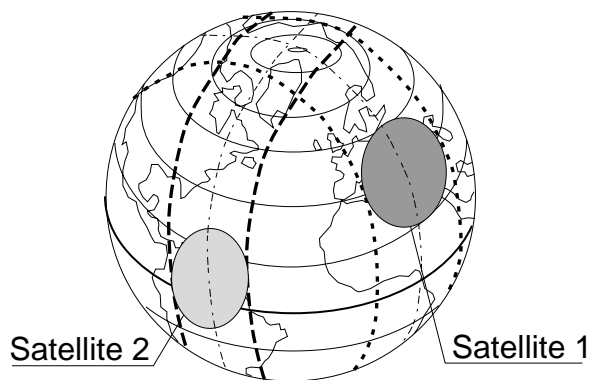
Figure 2 - Satellite swath

Because the orbit plane is essentially fixed in space for short time-periods and the earth rotates within the-orbit, two successive equatorial crossings are separated by 25° (i.e. 2,800 km) westbound. This distance between two successive sub-satellite tracks decreases with increasing latitude. Even at the equator, there is sidelap between successive swaths (figure 3). At approximately 82° latitude the track crosses the track of the previous orbit.
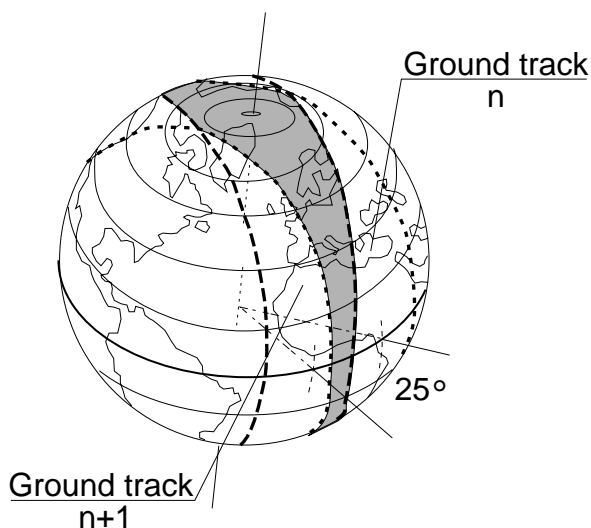
Figure 3 - Sidelap between successive swaths

A satellite pass directly over a transmitting PTT will be within view of that antenna for about 13 minutes, assuming that the satellite must be at least 5 degrees above the horizon to receive a signal. The average satellite pass duration is approximately 10 minutes and is independent of the PTT latitude. However, the number of satellite passes per day is strongly dependent on the PTT latitude. Table 5 gives the cumulated time of visibility and the number of satellite passes per 24 hours as a function of latitude.

Table 5 - Cumulative visibility and number of satellite passes per day as a function of latitude (with two satellite-system)

PTT latitude	Cumulative visibility over 24 hours (minutes)	Minimum number of passes per 24 hours	Mean number of passes per 24 hours	Maximum number of passes per 24 hours
0°	80	6	7	8
± 15°	88	8	8	9
± 30°	100	8	9	12
± 45°	128	10	11	12
± 55°	170	16	16	18
± 65°	246	21	22	23
± 75°	322	28	28	28
± 90°	384	28	28	28

Capabilities of the system and planned Enhancements

The capacity of a data collection satellite system is usually defined as the maximum allowable number of Data Collection Platforms (DCPs) which can transmit their data through the system.

For a Data Collection System (DCS) on board a geostationary environmental satellite (like GOES or Meteosat) the capacity is easy to assess because:

(a) All the DCPs are permanently in view of the satellite;

(b) Each self-timed DCP transmits at a regular assigned time;

(c) Each self-timed DCP is allocated a constant time slot for its transmission;

(d) Each DCP is assigned a transmission frequency chosen among a fixed number of channels.

Transmission time and frequency allocations are assigned to prevent any interference, so that each DCP transmission is certain to be relayed. Thus it is simple to deduce the maximum number of allowable DCPs (or DCS capacity) by multiplying the number of frequency channels by the number of time slots.

The Argos DCLS is greatly different from a geostationary DCS because:

(a) Only a limited number of the Argos PTTs can be received by the DCLS at a given time (5.7% of the earth's surface is viewed by the satellite) (instead of (a) above);

(b) The Argos PTT transmission times are randomly distributed as explained in Section 3.1 (instead of (b) above);

(c) The Argos PTT message durations are also randomly distributed between 360 and 920 ms, as explained in Section 3.1 (instead of (c) above);

(d) In the Argos system through satellite NOAA-J, all PTTs transmit on the same frequency (±3 kHz) but their received frequencies are randomly distributed. This is mainly due to different Doppler shifts associated with a random distribution of PTTs on the earth (instead of (d) above). Beginning with the new-generation NOAA-K, scheduled for launch in 1996, each PTT will transmit in channels within a ±30-kHz frequency band, making Argos more like a geostationary DCS as in (d) above.

Numerous ground simulations and in-orbit tests with the Argos DCLS have provided useful information concerning the variation of the probability of message acquisition as a function of:

(a) The number of PTTs simultaneously viewed by the satellite;

(b) The transmission rate of the PTTs;

(c) The PTT message duration.

In the latter half of the 1990's the Argos system will provide:

• more sensor data and locations by processing data from more satellites, and through such instrument enhancements as increased onboard capacity, wider receiver bandwidth, and more flexible management of transmitter repetition periods;

• greater sensitivity to low-power signals;

• relaying commands to transmitters, known as downlink messaging.

The Argos 2 instrument is currently slated for NOAA-K, L, M and N, with launches beginning in 1996. The down-link messaging capability will be added to Argos 2 on Japan's ADEOS II satellite in 1999. For the European METOP-1 satellite and NOAA-N' and beyond (2000+), plans are underway for Argos 3, which would incorporate still further enhancements. Included are changes related to management of the bandwidth such as the designation of spectrum for certain applications.

More sensor data and locations

In addition to the use of a stable oscillator in the transmitter design, data collection and location performance mainly depends upon:

(a) the number of operational satellites in orbit ,
(b) the satellite instrument design, and
(c) transmitter repetition periods and users' transmission strategies.

a) Increasing the number of operational satellites

- Since 1994, thanks to an agreement with NOAA, the Argos processing centers have been receiving data from a third satellite. This has increased the number of locations and amount of data received from platforms by 50%. The possibility to acquire additional data from standby satellites is currently under examination by NOAA. The launch of the ADEOS II satellite in1999 and the startup of the European METOP satellite series from year 2001, all with Argos instruments, will further increase satellite coverage.

b) Enhancing on-board instrument design

Increasing data processing capacity

- The Argos-2 generation of satellites starting with NOAA-K in 1996 will each carry eight processing units instead of four, and therefore will be able to process eight messages simultaneously. The transmission rate from the receiver to the recorder and downlink unit will also increase, from 960 to 2560 bits per second. In all, on-board instrument processing capacity will practically quadruple. This means that within a given satellite footprint either the number of platforms (or the number of messages they transmit) could be quadrupled.

- For the Argos-3 generation, starting with NOAA N', it is planned to provide a higher data rate. The current 400 bits per second (bps) rate could, for example, be raised to several thousand bps (kbps), and the message length increased. The design phase for Argos-3 is to be initiated in early 1996.

Wider frequency bandwidth

- From NOAA-K the bandwidth is being increased from 24 kHz to 80 kHz. Thus transmitter frequencies will be distributed in a much larger range, and signals reaching the satellite antenna will be more easily discriminated. For a given platform population more messages will be received intact.

  The idea is to split the bandwidth into three sub-bands, which could be allocated to different types of applications:

  - an upper band for transmitters requiring high data rates and without power limitations,

- a lower band for low-power transmitters such as those used for animal tracking,

- a middle band for all other applications, in particular for users with first-generation transmitters.

• With Argos-3, bit rates could be different in each band, i.e. high in the upper band, 400 bps (current rate) in the middle one, and lower rates in the low end of the band in order to reduce power consumption.

Using downlink messaging for message acknowledgement

• With Argos-3 it is foreseen to use the downlink messaging facility to acknowledge messages sent by the transmitters. An acknowledgement message will be sent to the transmitter for each message received error-free by the on-board instrument. The transmitter will no longer repeat each message several times, thus more data can be collected within a given satellite pass. This capability will be dedicated to applications really needing it.

c) Transmission repetition periods and users' strategies

Another way of improving data collection and location capability is to "tune" platform transmission.

Two factors have reduced the number of transmissions sent to the satellites, freeing capacity for other Argos applications:

• Since the system began operating in 1978, Service Argos has gradually increased repetition periods for location-type transmitters, from 40 seconds to 90 seconds. This has been achieved by upgrading the Doppler location software at the Argos processing centres while increasing location accuracy.

• Many users' transmitters now operate in duty cycles to conserve battery lifetime, for example transmitting for eight hours a day, six hours in every three days, etc.

Today average use of the Argos onboard instrument capacity worldwide is around 15%. The highest use is about 55% in the North Atlantic see chart attached for May 1995 (figure 4).

Figure 4 - Argos system duty coefficient for May 1995

Since the on-board instrument capacity will quadruple from NOAA-K, this means that spare capacity is already available and will be increased with Argos-2. It can be used to improve data collection and location capabilities through the use of shorter repetition periods.

Sensitivity to low-power signals

The Argos instrument on-board existing NOAA satellites features a receiver with sensitivity of -128 dB. Beginning with NOAA-K (1996), the instrument sensitivity will increase to -131 dB. This means that lower power signals can be received by the satellite, reducing transmitter power requirements. In theory, the power requirement will go down by approximately 50%, thus a 1 watt transmitter could be reduced to 500 milliwatts (all other conditions being equal).

For some applications (such as Biology), where very low-powered transmitters are used, a special channel could be reserved from the expanded Argos bandwidth. To minimize interference from other transmitters, very low-power units would be programmed to broadcast on this part of the Argos band.

In general, higher sensitivity will result in more messages being received at the satellite. It will also allow the spacecraft to receive messages for low-power transmitters more distant than is currently possible. The relationship between signal strength and PTT-to-spacecraft distance is a well known phenomenon. For very low-powered transmitters, messages sent at the beginning and end of each pass (low elevation passes) may be too low in power to be received. For these PTTs, the stated 5,000 Km footprint is effectively reduced. Increasing sensitivity will allow more of these marginal messages to be received, effectively resulting in longer pass duration and better chances for successful location computation.

The impacts of the higher sensitivity are broad in scope in that the general population of Argos transmitters will require less power. This transition should occur gradually as the existing inventory of transmitters is replaced. More immediate benefits will be gained by applications requiring very low power or transmitters in "marginal" situations. For these, the constraints presented by existing power requirements will be relaxed.

For instruments beyond NOAA- M and ADEOS II, there may be further opportunity to improve sensitivity. Discussions are under way to consider another 3 dB reduction, possible with existing technology. In addition, more sophisticated management of the bandwidth could achieve further benefit by reducing the bit rate for transmitters operating on the low-power "channel".

Downlink Messaging

Plans for future Argos instruments are to include a down-link messaging capability thereby establishing two-way communication. Down-link messaging will enable Users to send brief commands to their platforms. The commands could be used to simply turn

transmitters on or off, or to perform more complicated tasks. For example, sensors could be controlled, measurement modes could be changed, and transmitters could be programmed, ID numbers could be changed. Messages could be broadcast, for example housekeeping data such as orbit predictions sent to all platforms, messages sent to particular groups of platforms (group calls)

The downlink signal can be used by yhe platforms to detect the arrival of the satellite.

All messages to be forwarded to platforms would be sent through one of the Global Processing Centers. Messages would be uploaded to the next available satellite and retransmitted either immediately or at a designated time, depending on the message type. Users would submit their requests for a down-linked message much like current requests for changes to processing options.

This capability will be introduced on the Japanese satellite, ADEOS II, to be launched in late 1999 (an agreement to carry Argos on ADEOS II was signed in early 1995). Down-link messaging would be accomplished by converting one of the 8 Argos data recovery units to communicate in the opposite direction. This presents the first opportunity to install a two-way capability into the Argos system. Beyond ADEOS II, the Argos 3 instrument would incorporate down-link messaging along with other improvements, currently under discussion.

3.3 -   Telemetry acquisition

The Argos DCLS data, within the TIP output data flow, are transmitted to the ground via three different downlinks:

   (a) In real time, the TIP output (8.32 kbits/sec) modulates directly a VHF-beacon onboard and transmits continuously;

   (b) In real time, the TIP output is multiplexed, on board the with the High Resolution Picture Transmission (HRPT) data and transmitted continuously via the real-time S-Band downlink;

   (c) The TIP output is also stored on one of the onboard tape recorders. Each time the satellite passes over a telemetry station the data recorded on tape are read out and transmitted to the ground via the S-Band-playback downlink.

These three links are summarized in Table 7.

Table 7 - Argos DCLS data communication links

Link	Carrier frequency (MHz)	Signal source	Data rate (kbps)	Modulation	Radiated power (W)
VHF direct readout	136.7 or 137.7	TIP	8.32	Biphase/PM	1.0
Real-time, S-band	1698.0 or 1707.0	HRPT	665.4	Biphase/PM	5.25
Delayed time S-band	1698.0 or 1702.5 or 1707.0	Recorded data	2661.6	NRZ/PM	5.25

Argos telemetry acquisition and ground transmission

Global coverage (playback of recorded data)
The satellites receive and record users' message data. They play back the data each time they pass over one of the three ground stations: Wallops Island, Virginia, USA; Fairbanks, Alaska, USA; and Lannion, France. The data are transmitted to NESDIS in Suitland, Maryland, or *Météorologie Nationale* in Lannion where they are separated from other satellite instrument data. They are then forwarded to the Argos Global Processing Centres in Toulouse, France and Landover, MD. The data are processed to calculate transmitter locations and interpret sensor outputs, then the results are made available to users. On average, over three-quarters of the processed results are available to users within three hours of receipt by the DCLS.

Regional coverage ("live" retransmissions)
The Argos processing system also receives PTT messages in real time, i.e. when a ground station and PTT are simultaneously in satellite visibility. The Wallops Island, Fairbanks, and Lannion stations provide regional coverage, as do other stations connected to the Argos system in the United States (Hawaii) and Australia (Casey, Darwin, Melbourne and Perth). The messages are processed in near-real time: users often receive results less than 20 minutes after collection by the DCLS.

Figure 5 shows the regional coverage areas for the current ground stations.

Figure 5 - Argos regional coverage areas.

FAIRBANKS

TOKYO

Hawaii

WALLOPS ISLAND

LANNION

DARWIN

PERTH

MELBOURNE

CASEY

90°
60°
30°
0°
30°
60°
90°

180°   -90°   0°   90°

Area in which:

over 50% } of messages received
in global coverage mode
over 30% } are retransmitted in real time
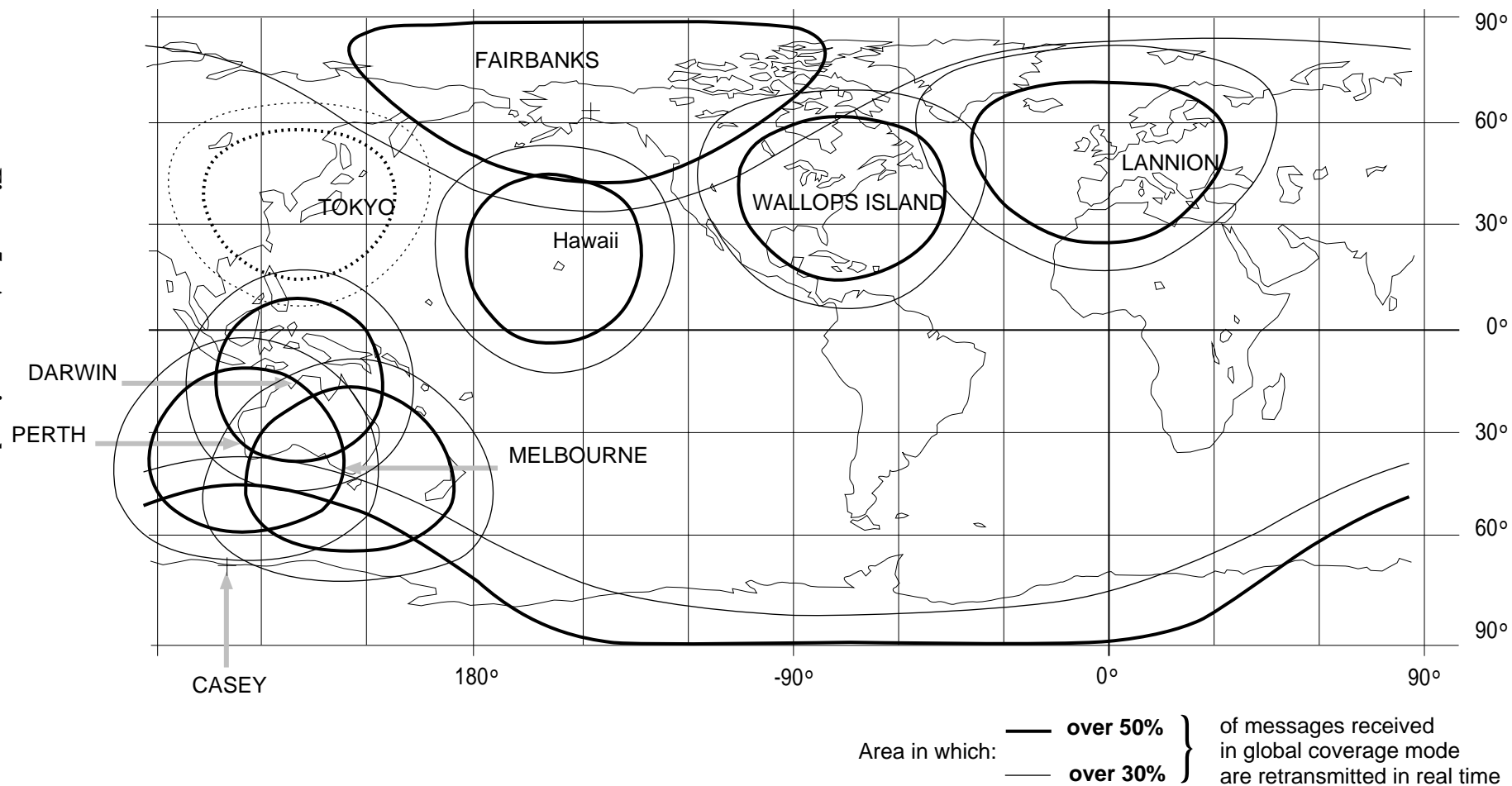
4 - ARGOS DATA PROCESSING

All Argos data received from the satellites are sent to the Argos GPCs in Toulouse, France (FRGPC) and Landover, MD (USGPC). The following processing tasks are then performed:

(a) Decoding of the PTT messages and processing of the sensor data;

(b) Computation of PTT locations from Doppler shifts and orbital data;

(c) Storage of all these processing outputs on computer files.

4.1 - Sensor data processing

Sensor data processing by the Argos GPCs comprises three steps:

(a) Sensor data pre-processing, compression of identical messages and message time coding in Universal Coordinated Time (UTC).

(b) Standard sensor data processing: converting the binary messages into user-defined units, each sensor's data being processed independently of the others.

(c) Special processing of PTT messages which cannot be converted into user-defined units by standard processing: each special processing procedure is completely defined by the user and concerns the sensor data field as a whole.

To be compatible with the Argos GPCs' sensor data processing software the sensor data must satisfy the following rules (in addition to the general format specification given in Section 3.1):

(a) The sensor data part of a PTT message can contain from 1 to 8 blocks of 32 bits each.

(b) A PTT can have from 1 to 32 sensors which may overlap block boundaries.

(c) Each sensor can generate 1 to 32 bits provided the above-mentioned conditions are met.

Developments in sensor processing take place from time to time, and potential users are urged to make early contact with an Argos User Office to determine the options available.

Message pre-processing

(a) Compression of identical messages received from a platform during a pass. Compression consists in comparing the data, message by message and bit by bit. Only the last received message in a series of identical messages is processed. The number of identical messages in the series (the "compression index") is also stored and is available to users.

(b) UTC coding of the message acquisition. Message processing by the Argos satellite DCLS involves the time measurement of the message acquisition by the DCLS clock. This onboard DCLS clock is synchronized with the FRGPC master clock using the messages transmitted by a reference PTT at Toulouse. After message pre-processing, the message acquisition time is expressed in UTC and is available to users with a standard resolution of one second. On request, Argos can time-code sensor data in milliseconds (UTC time), according to the instant at which the satellite received the PTT message.

Standard sensor data processing

The two types of standard sensor data processing are Type A and Type B. For each sensor data set being processed the user has to define for each individual sensor the processing option and parameters:

(a) Type A: This processing performs the conversion of the binary received data into user-defined digital codes. This standard processing is sub-divided into standard options defined as indicated in Table 8.

Table 8 - Standard type A processing options

Option	Data received	Processed data
A1	Binary	Decimal
A2	Binary	Hexadecimal
A3	Binary	Octal
A4	BCD	Decimal
A5	Gray code	Decimal

(b) Type B: This converts the primary received data into user-defined physical units and uses the calibration information specific to that sensor for reference. The processed output data are available to the users in a standard scientific notation form (also called floating point notation) with five significant digits. The physical value thus determined is then compared with the upper and lower limits fixed by the user. The results of this comparison can be used as an indication of the quality of the data received.

Different types of processing are available:

- Type B1: Consists essentially in the linear interpolation between tabulated values supplied by the user.

- Type B2: Is used to compensate one sensor by another using a table of values supplied by the user.

- Type B3: Is used to compensate one sensor by another using a mathematical formula. Coefficients are supplied by the user.

- Type B4: Uses a double polynomial. Any sensor can be compensated by any other sensor having a polynomial transfer function.

4.2 - Location processing

Platform location is determined using the received frequency Doppler shifts.

Since the transmission frequency is fixed for all platforms, the satellite receive frequency at any instant can be used to define the field of possible positions for a platform. The field is in the form of a half-cone, with the satellite at its apex, the satellite velocity vector as axis of symmetry, and the apex half-angle (A) such that:

$$\cos(A) = \frac{(f_r - f_e)c}{f_e \cdot V}$$

where:
    c = speed of light
    V = satellite speed relative to platform
    f_e = transmission frequency (401.650 MHz)
    f_r = receive frequency

A location cone is obtained for each Doppler measurement. The location cones intersect the platform's height ellipsoid to yield two possible positions, which are symmetrical with respect to the satellite ground track. To find which position is correct, additional information is required, for example previous locations, range of possible speeds, etc.

Orbit prediction

Eleven special orbit determination beacons are installed at appropriate locations over the earth. The geodetic location of each of these sites has been accurately determined. These beacons have very stable oscillators. A reference beacon in Toulouse transmits very accurate time and frequency reference signals.

Twice a day the satellite orbit parameters are adjusted using the orbit determination beacons. The orbit is then extrapolated to the following day. The orbit prediction accuracy is checked continually by comparing the predicted location of the reference PTTs with their true location.

Number of locations per day

As for data collection, the number of location fixes per day is a function of PTT latitude and whether the user has chosen the optional three-satellite service. Table 9 gives the average number of successful location fixes a day, assuming the elementary probability of message acquisition by the satellite is 0.8.

Table 9 - Average number of location fixes per day

Latitude	Number of locations	
	With two satellites	With the optional three-satellite service
0°	5.5	8
10°	6	9
20°	6	9
30°	7	10.5
40°	7.5	11
50°	9	13.5
60°	13	19.5
70°	18	27
80°	20	30
90°	28	42

Location accuracy

The main factors that can reduce Argos location accuracy are:

(a) Orbit prediction error.

(b) Medium-term PTT oscillator drift (refer to Section 3.1) which produces a location bias.

(c) Short-term PTT oscillator instability (refer to Section 3.1) which produces a random location error.

(d) Error in the altitude of the platform to be located, negligible for buoys and ships.

<u>Location accuracy classes</u>

Location accuracy depends on:
- the PTT oscillator quality: short and medium-term stability (see Section 3.1 above),
- the pass geometry when the satellite receives the messages: PTT distance from satellite ground track, spread of messages during the pass.

Standard locations are graded into classes (Table 10) according to their accuracy, from Class 3, accurate to within 150 m, down to Class 0 in which the error exceeds 1000 m. The default option for users is to receive classes 3, 2 and 1. Users can also state minimum requirements, e.g. only class 2 or better.

Extra locations are available from an optional service called Location Service Plus (known as Auxiliary Location Processing in North America). This calculates locations from two messages or three, instead of the four used for Standard processing. It also provides diagnostic information on transmissions, e.g. received signal strength, and other functions.

Table 10 - Classes of Argos Location Accuracy

Service	Class	Conditions	Location accuracy estimated
Standard location	3, 2, 1, 0	• 4 messages must be received during the satellite pass • location result must pass at least 2 of the 4 plausibility tests	Yes
Optional extra locations from Location Service Plus (Auxiliary Location Processing in North America)	A	• 3 messages • 2 plausibility tests are done	No
	B	• 2 messages • 2 plausibility tests are done	No

Location Service Plus also provides the locations rejected by the Argos location calculation.

4.3 - Argos data files

The Argos GPC performs sensor data processing and location processing in parallel. The output of these two operations is stored in a master data bank which contains all the data acquired over the last 100 days. The data are sorted by programme, PTT and date and are stored on magnetic disks. The disks are processed every two weeks to generate

the offline products described in Section 7. The data are also available on line (see Section 6) in their original form or after further processing, such as compaction.

Data compaction

Data compaction removes redundant messages and consists simply of retaining the most useful or significant sensor data message from each PTT. Argos processing selects messages as follows:

(1)   Select message with the highest compression index (i.e. number of consecutive, identical messages received) as explained in Section 4.1.

(2)   If several messages still remain, select the most recent message, except if compression index = 1 in which case avoid the last message if possible.

5 - DEDICATED ARGOS GTS SUB-SYSTEM

A dedicated GTS Sub-system is operated at both the FRGPC, Toulouse, and the USGPC, Landover, MD. Platform sensor data are decoded, processed in geophysical units, quality controlled, encoded in WMO code formats and disseminated onto the GTS in real time.

The Argos GTS sub-system is separate from the Argos System (see figure 6 below);however, both systems reside and operate on Argos equipment and Service Argos is responsible for maintenance of GTS software. Hence data delivered to the owners of the stations and data disseminated on GTS can be processed in different ways. For example, owners can receive the raw data on line from an Argos centre, and at the same time have geophysical units sent through the GTS sub-system for GTS distribution.
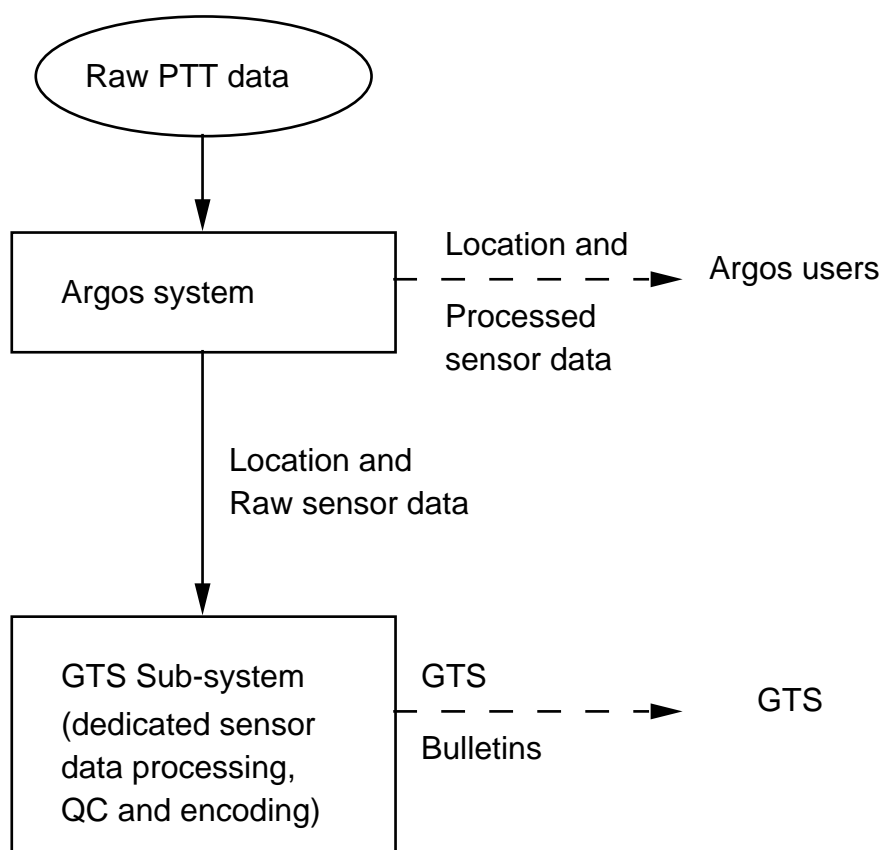
Figure 6 - Argos system and GTS sub-system

5.1 - Sensor data processing

The GTS sub-system processes sensor data flexibly. For example, sensor binary outputs can be placed in any order in the Argos message transmitted by the platforms. Sensor

binary output is limited to 32 bits. Users should submit transfer functions in a form compatible with the B1, B2, B3, and B4 data processing options described in Section 4.1. However, other options are available if these standard processing types do not provide sufficient accuracy.

The GTS sub-system can also process Date/Time information.

5.2 - Quality Control

Thanks to several automatic Quality Control (QC) checks, erroneous data are detected and removed from GTS distribution. These QC tests, which can be turned off on request, are:

(a) Gross Error check. Sensor data are compared with constant limits. The present gross checks are indicated in Table 11:

Table 11 - Gross error checks operated at the Argos GTS sub-system

Parameter	Lower limit	Upper limit
Sea level air pressure (hPa)	800	1080
Station air pressure (hPa)	400	1080
Air pressure tendency (hPa/3H)	0	100
Water temperature (deg)	- 1.8	+ 45
Air temperature (deg)	- 80	+ 50
Wind speed (m/s)	0	100 (see note)
Wind direction (deg)	0	360

NOTE: Wind speed values which exceed 99 units (knots or m/s, as requested) and can be expressed in BUOY code (e.g. 99 knots) will be transmitted as 99.

(b) User Limits check. The limits are provided by the owner of the platform for each sensor on each platform;

(c) Sensor blockage test. Same sensor value reported consecutively a certain number of times during a certain period (this test is normally used only for Air Pressure sensors);

(d) <u>All bits identical test</u>. All the bits of the sensor binary output are ones or zeros (this test is usually not used for Wind Speed, Wind Direction or Pressure Tendency);

(e) <u>Compression Index by sensor</u>. At least two identical sensor values for a satellite pass must be received (values don't have to be consecutive);

(f) <u>Checksums</u>. If the option is used, the sum encoded in the Argos message must still be consistent upon reception at the Argos centre. If not consistent, the data are not distributed on the GTS.

In addition, the following procedures are applied:

(a) If GTS dissemination of the station location is required, only the location with the highest probability of being correct is transmitted;

(b) If GTS dissemination of the station location is required, when location processing is not performed during a satellite pass, the last known location is provided;

(c) For drifting buoys, data with location more than 48 hours old are not transmitted via the GTS (24 hours for ships, longer periods or no limit for other types of platforms).

5.3 - GTS distribution

Sensor data measured at the same time for the same platform are grouped and encoded into single GTS reports. GTS reports encoded using the same WMO code are grouped into bulletins. Bulletins are transmitted directly to Météo-France, Toulouse, and to the National Weather Service, Washington, D.C. for dissemination over the GTS. The FRGPC is linked to the GTS Regional Telecommunication Hub (RTH) in Toulouse via the Transpac data network (9600 bps). The USGPC uses a 9600 bps dial-up line to the National Weather Service telecommunications gateway (NWSTG) in Silver Spring, Maryland. Mainly depending upon the type of data being transmitted, the following GTS code formats can be used for GTS distribution:

FM 12-X SYNOP	Report of surface observation from a land station,
FM 13-X SHIP	Report of surface observation from a sea station,
FM 18-X BUOY	Report of a buoy observation,
FM 63-X Ext. BATHY	Report of a bathythermal observation,
FM 64-IX TESAC	Temperature, salinity, and current report from a sea station,
FM 67-VI HYDRA	Report of hydrological observation from a hydrological station.

These codes are described in publication WMO-No. 306, Volume I, and reproduced partially in Annex III.

5.4 - GTS codes used with Argos
(see annex III for detailed description)

Below are the geophysical variables that the Argos GTS Sub-System can handle, physical units for the calibration curves, and GTS codes in which they can be distributed on the GTS.

Mnemo	Variable	Units	Buoy	Synop	Ship	Bathy	Tesac	Hydra	Bufr
AI_GEOP	Geopotential	M		*	*				*
AI_HUM	Air Relative Humidity	%	*	*	*				*
AI_P	Atmospheric Pressure	hPa	*	*	*				*
AI_PT[1]	Air Press Tendency (>0)	hPa/3H	*	*	*	*			*
AI_PTC[1]	Charact of Pr. Tend.	Table	*	*	*				*
AI_PV[1]	Air Press Variation	hPa/3H	*	*	*	*			*
AI_SLP	Sea Level Pressure	hPa	*	*	*				*
AI_T	Air Temperature	C	*	*	*	*	*	*	*
AI_TD	Air Dew Point	C	*	*	*			*	*
AI_TN06	Air Temp (Min.) in 6 hrs	C		*	*				*
AI_TN12	Air Temp (Min.) in 12 hrs	C		*	*				*
AI_TN24	Air Temp (Min.) in 24 hrs	C		*	*			*	*
AI_TX06	Air Temp (Max.) in 6 hrs	C		*	*				*
AI_TX12	Air Temp (Max.) in 12 hrs	C		*	*				*
AI_TX24	Air Temp (Max.) in 24 hrs	C		*	*			*	*
ALTITUDE	Altitude of station	M							*
CU_DI, l<0[2]	Current direction	Deg	*				*		*
CU_DI, l=0[2]	Surface Current Dir.	Deg	*			*	*		*
CU_SP, l<0[2]	Current Speed	cm/s	*				*		*
CU_SP, l=0[2]	Surface Current Speed	cm/s	*			*	*		*
DISCHARGE	Discharge hydro sta.	dm^3/s						*	*
HK#1	Housekeeping Param.	Free	*						*
HK#2	Housekeeping Param.	Free	*						*
HK#3	Housekeeping Param.	Free	*						*
H_VISI	Horizontal Visibility	m		*	*				*
LATITUDE	North Latitude of platform	Deg.	*		*	*	*		*
LONGITUDE	East Longitude of platform	Deg.	*		*	*	*		*
PRECIP01	Precipitations in 1 hr.	mm		*	*			*	*
PRECIP02	Precip. in 2 hours	mm		*	*			*	*
PRECIP03	Precip. in 3 hours	mm		*	*			*	*
PRECIP06	Precip. in 6 hours	mm		*	*			*	*
PRECIP09	Precip. in 9 hours	mm		*	*				*
PRECIP12	Precip. in 12 hours	mm		*	*			*	*
PRECIP15	Precip. in 15 hours	mm		*	*				*
PRECIP18	Precip. in 18 hours	mm		*	*				*
PRECIP24	Precip. in 24 hours	mm		*	*			*	*

Table continues on next page...

[1] If an Air Pressure Tendency (AI_PT, always positive) sensor is used, it should be in conjunction with a Characteristic of Pressure Tendency (AI_PTC) sensor (see group **appp** in annex III.1, III.2, III.3, and III.4). If no Characteristic of Pressure Tendency sensor is used, then an Air Pressure Variation Sensor (AI_PV) should be used instead (positive or negative).

[2] In the table above, "l=0" means measurement made at sea surface, and "l<0" means measurement made below the sea surface.

... Continued from previous page

Mnemo	Variable	Units	Buoy	Synop	Ship	Bathy	Tesac	Hydra	Bufr
SNOW_DEPTH	Depth of Snow Layer	cm		*					*
SNOW_WAT24	Snow in 24h Wat Equiv	mm						*	*
SNOW_WATER	Snow Layer Wat Equiv	mm						*	*
STAGE	Stage hydro. station.	cm						*	*
TIDE_GAUGE	Sea Level	m							*
WA_HT	Wave height	m	*	*	*				*
WA_PE	Wave period	s	*	*	*				*
WIWA_HT	Wind wave height	m		*	*				*
WIWA_PE	Wind wave period	s		*	*				*
WI_DI	Wind direction	Deg	*	*	*	*	*		*
WI_GU	Wind gust at the obs.	m/s		*	*				*
WI_GU01	Wind gust in prev. hour	m/s		*	*				*
WI_GU03	Wind gust in prev. 3 hours	m/s		*	*				*
WI_SP	Wind Speed	m/s	*	*	*	*	*		*
WT_SA, $l<0$[2]	Water Salinity	ppm	*					*	*
WT_SA, $l=0$[2]	Mixed Layer Salinity	ppm	*					*	*
WT_T, $l<0$[2]	Water Temperature (probe)	C	*			*	*		*
WT_T, $l=0$[2]	SST (hull contact)	C	*	*	*	*	*	*	*
WT_T_BUCK	Water temp. (bucket)	C		*	*				*
WT_T_INTK	Water temp. (intake)	C		*	*				*
WT_T_OTHER	Water temp. (other than -T, -T-INTK or -T-BUCK)								
		C		*	*				*

Remarks:

(a) BUFR is not available yet.

(b) The BUOY code replaced the DRIFTER code on 2 November 1994 and is no longer used.

(c) National Regional Sections of GTS character codes listed above are not presently implemented within the Argos GTS sub-system.

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[2] In the table above, "$l=0$" means measurement made at sea surface, and "$l<0$" means measurement made below the sea surface.

5.5 - Requirements and procedures for GTS dissemination of buoy data

Deployers of drifting buoys are encouraged to make the data obtained from their buoys available to the global user community, both operational and research, by disseminating data over the GTS. Basic rules for contributing data to the GTS:

(a) The programme must have had prior Argos formal agreement (see Chapter 9) and the sensor data must have meteorological or oceanographic value as defined below;

(b) The data must be capable of being transmitted in one of the WMO codes listed in Sections 5.3 and 5.4,

(c) Programme owners must have contacted their National Weather Service and/or National focal point for drifting buoy programmes (see Annex IV) so that national procedures for inserting data onto the GTS are followed. In particular, WMO identifiers have to be assigned to each platform in accordance with WMO rules (see Section 5.6 and Annex II);

(d) The PTT owner/operator must pass these WMO identifiers to Service Argos, when the PTTs have become operational, so that GTS transmission may commence;

(e) Necessary information for decoding the Argos messages and converting the sensor data into physical units must be provided to Service Argos (i.e. Argos message format, calibration curves). A GTS Technical file is available from the Argos User Offices.

(f) After deployment, deployers must carry out quality control of data obtained, and if satisfactory:

    (i) tell Service Argos when the buoys are to start transmitting operationally,
    (ii) ask Service Argos to transmit the data through the GTS;

(g) Inform the WMO Secretariat, through their national Meteorological Service, about the deployment date(s) and buoy characteristics.

5.6 - Identifier numbers

Individual drifting buoys and other platforms are identified by Argos-assigned numbers built into the PTTs. In addition, when data from these platforms are intended for transmission through the GTS, another identifier called "WMO international buoy identifier number" - $A_1 b_w n_b n_b n_b$ is used in place of the Argos identifier (see Annex II).

For the allocation of these identifiers deployers must receive their PTT numbers from Service Argos and the WMO number from their national Meteorological Service or

National Focal Point for Buoy Programmes, or designated person for the country. See Annex IV for addresses and telephone numbers. Please contact the Technical Coordinator of the Data Buoy Coperation Panel for delails or assistance (references in annex VI).

5.7 - WMO standard format for routine meteorological messages

In order to effectively and rapidly transmit drifting buoy data over the GTS, the WMO standard telecommunication procedures, as described in the Manual on the GTS, should be followed. In particular, meteorological messages containing drifting buoy data should be in accordance with the WMO procedures concerning message formats, as follows:

• Meteorological messages should consist of:

Starting line:	ZCZC nnn		* (1)
Abbreviated heading:	$T_1T_2A_1A_2ii$ CCCC	YYGGgg	*(2)
Text:	Each report shall start at the beginning of a new line and shall be separated by a meteorological report separation signal (=)		
End-of-message signal:	NNNN		*(1)

NOTES: (1) ZCZC and NNNN are replaced by SOH and ETX control characters respectively for messages transmitted in International Telegraph Alphabet N° 5.

   (2) T_1T_2 = SS indicates bulletins containing drifting buoy data, AA indicates a geographical area from which data are available, ii = 01 - 19 indicate bulletins for global exchange, CCCC indicates a centre from which a bulletin is originally injected into the GTS, YYGGgg is the date-time group.

6 -   ON-LINE ACCESS TO ARGOS DATA

6.1 -   Over the Global Telecommunication System

See Section 5.

6.2 -   Other on-line modes

a)   **Automatic Distribution Service.** This optional service delivers users' results straight to their desktops in accordance with their requirements:
- by the channel required, e.g. X.25 data network, fax, etc.,
- to the user only or also to colleagues anywhere in the world,
- all platforms in the program, or selected individual platforms,
- one result from each satellite pass or all messages,
- with or without data compression,
- at scheduled intervals or every time new results are available,
- etc.

At the time of writing (September 1994), the channels for users to access results are:
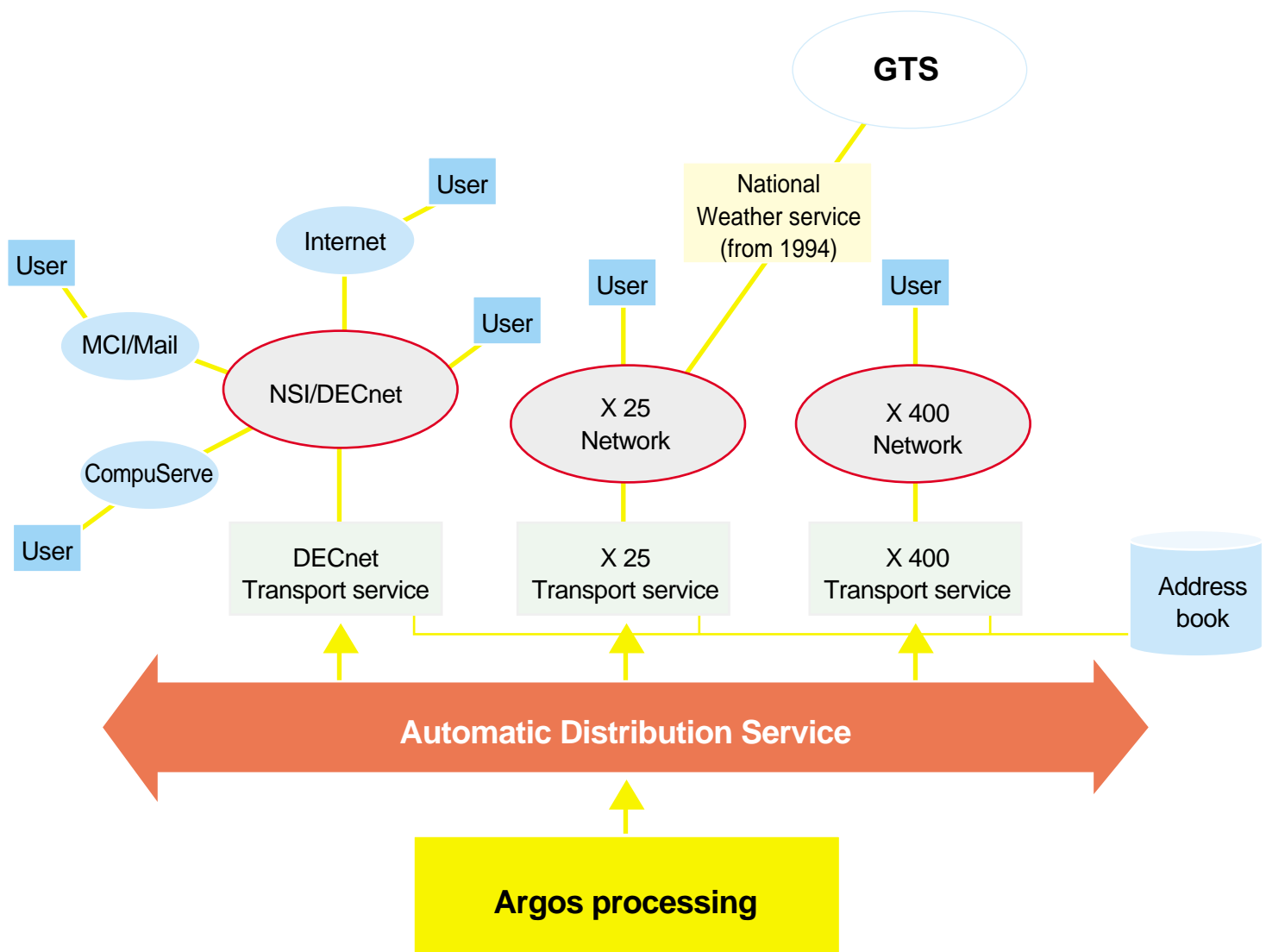
Figure 7 - channels for accessing Argos results via Automatic Distribution Service

(b) **Data networks**. North American users can access the USGPC through the TYMNET transmission network, and users of other countries can access the FRGPC through TRANSPAC. Via the International Transit Node (ITN), TYMNET and TRANSPAC are linked to many networks, such as EURONET in Europe, DATAPAC in Canada and TELENET in North America. These networks offer excellent security and availability, thanks to extensive inter-linking. They are also cheaper than conventional telephone or telex links. The number of networks of this sort continually increases. Users must connect into their national public data transmission network and have their own subscription. They need a modem meeting national standards. Since the call procedure can vary from one network to another, users should obtain the necessary information from their national network operator.

(c) **International telephone network.** To connect to the FRGPC a modem meeting European standards (CCITT V21) is needed. The North American user calls a local TYMNET number according to the speed used, then the USGPC number. A modem meeting American standards (Bell 103) must be used.

(d) **International telex network.** The user may call either TYMNET (in North America) or TRANSPAC (outside North America) by dialling the appropriate telex number, then use the standard connection procedure to access their data. The data transmission rate is limited to 50 bps.

The data can be printed or stored in computer memory. The interrogation procedure can be performed manually or programmed on a computer.

Dual processing

Dual processing means the user's data are processed at both the FRGPC, and the USGPC at the same time. The advantage is that the data are available for access at both centres. For example:
o a user in Boston can connect to Landover to obtain results generated by colleagues in Düsseldorf;
o a user in Düsseldorf can connect to Toulouse to obtain results generated by colleagues in Boston.

7 - ARGOS OFF-LINE RESULTS

Users whose results are not time-critical receive them off line from the Argos databank every week or every month. They can also access the last three months of data plus the current month. The data are arranged programme by programme, then PTT by PTT within each programme, and in chronological order for each PTT.

Results are available on tape, floppy disk or paper (Table 12):

Table 12 - Available Media for Receipt of off-line Argos Data

Medium	Type	Approx. capacity
Tape	1200-foot	20 MB
	2400-foot	40 MB
Floppy disk	5.25"	720 KB
	3.5"	1.2 MB
Paper	standard business stationery	

Two standard and two optional data formats are available:

Standard formats:

• **Full DS**: this provides:
 - sensor data,
 - locations in classes 3, 2, 1 and 0,
 - locations in classes A and B for subscribers to Location Service Plus (Auxiliary Location Processing in North America) described in Section 4.2.

The results appear as follows:

```
10 10000 2 1 D 3  1993-03-03 13:34:36 48.364 355.452 0.000 401649662
     1993-03-03  13:38:57   6     00
10 10000 3 1 H
     1993-03-03  13:40:29   1     10
     1993-03-03  13:46:30   4     20
```

Record 1: message received by satellite NOAA-D

`10`	program number
`10000`	transmitter ID number
`2`	number of lines of results
`1`	number of sensors
`D`	name of satellite, i.e. NOAA-D
`3`	location class
`1993-03-03`	date (Year, Month, Day) of location obtained during the pass

`13:34:36`	time-code (Hours, Minutes, Seconds) of location, in UTC time
`48.364`	transmitter latitude in degrees and thousandths of a degree
	figure is positive for northern hemisphere, negative for southern
`355.452`	transmitter longitude in degrees and thousandths of a degree
`0.000`	transmitter altitude in km, used in location calculation, as supplied in user's Technical File
`401649662`	calculated transmit frequency
`1993-03-03`	date (Year, Month, Day) of data collection
`13:38:57`	time-code (Hours, Minutes, Seconds) of data collection, in UTC time
`6`	number of identical messages received
`00`	value of sensor #1

Record 2: message received by satellite NOAA-H
etc.

• **Simplified DS**: same as full DS except it includes only the best data collection message in each satellite pass. This is the message received consecutively in identical form the most often (message with the highest compression index). Simplified DS format reduces the volume of data by roughly three-fourths, and therefore reduces cost.

• Optional formats **DIAG** and **PRV/A** for subscribers to Location Service Plus (Auxiliary Location Processing in North America). These provide:
   - "Z" type results, rejected by the Argos location calculation,
   - diagnostic information on transmissions, e.g. received signal strength.

8 -   QUALITY CONTROL

The primary responsibility for data quality control lies with the owner of the platform from which the observation originates. In many cases this will be a national meteorological service, an oceanographic institute or a principle investigator for a particular research project (In this last case often acting on behalf of the legal owner). It is especially important that data entered on the GTS are quality controlled by the originator of the observation. To detect errors which may escape national quality control systems and errors introduced subsequently, national meteorological services should ensure that Regional Meteorological Centres (RMCs) and World Meteorological Centres (WMCs) also carry out appropriate quality control of observational data they receive.

Drifting buoy deployers are requested to quality control the data from their buoys during the initial testing period (see Section 5.5). For operational drifting buoy data entered onto the GTS through the RTH Toulouse and NWSTG Washington, Météo France and the National Weather Service of the USA, respectively, are responsible for quality control. Drifting buoy data received through LUTs and entered operationally onto the GTS by the LUT operator should also undergo initial quality control by the relevant service or individual.

Because of the global nature of meteorological data entered onto the GTS by Service Argos, special arrangements for quality control have been developed and implemented, by Service Argos and by the USA NOAA National Data Buoy Center (NDBC) for all systems NDBC operates and maintains.

All Argos data disseminated on GTS automatically go through various dedicated Quality Control checks. Erroneous data are not distributed on the GTS. Refer to Section 5.2 for the list and description of these tests.

At NDBC all GTS data, including those obtained via Service Argos, are further examined to detect anomalies in the time continuity of the sensor values and to make more subtle comparisons with other observational and archived data.

In addition, deferred time Quality Control Guidelines were implemented by the DBCP in January 1992. Principal Meteorological or Oceanographic Centres (PMOC) responsible for Quality Control of GTS buoy data detect any buoys reporting erroneous or biased data onto the GTS. Hence, status change proposals are sent regularly via an Internet distribution system to cooperating individuals and relevant services, including, in particular, the Technical Co-ordinator of the DBCP. The Technical Co-ordinator of the DBCP can then contact the owner of the platforms and suggest the change. The QC Guidelines considerably shorten the time needed to fix problems. The following centres are presently acting as PMOCs:

- Météo-France,
- The Australian Bureau of Meteorology,

- The European Centre for Medium-Range Weather Forecasts,
- The Icelandic Meteorological Office,
- The Japan Meteorological Agency,
- The Meteorological Service of New Zealand, Ltd.,
- The NOAA National Data Buoy Center,
- The NOAA Ocean Products Center,
  The South African Weather Bureau,
- The United Kingdom Meteorological Office.

9 - ADMISSION TO THE ARGOS SYSTEM

9.1 - Introduction

The Argos data collection and location system is operated in accordance with a memorandum of understanding (MOU) among the two agencies participating in the operation of the system:

- The National Oceanic and Atmospheric Administration (NOAA, USA)
- The Centre National d'Etudes Spatiales (CNES, France).

The participating agencies are jointly represented by the Argos Operations Committee (OC). Under the supervision of the Argos OC, the system is operated in accordance with the MOU, by CLS in France and by Service Argos, Inc. in the USA. The main technical functions of CLS/Service Argos are:

(a) Interface with CNES for the certification of newly-designed PTTs.

(b) Monitor PTT transmissions.

(c) Operate and maintain the orbit determination network.

(d) Monitor and control the Argos onboard equipment.

(e) Process the sensor data collected for distribution on the GTS and to users.

(f) Determine PTT locations.

(g) Disseminate meteorological data over the GTS.

(h) Generate data files for users to access on line.

(i) Generate and maintain archives.

Before deploying a new PTT, the PTT operator must take part in three administrative steps which constitute the "admission" procedure. Each operator must:

• Complete an application form which must be approved and signed by both the USA and French co-chairmen of the OC. Once this approval is granted, Service Argos establishes the mode of support required for the newly admitted PTT.

• Complete a Technical File which describes in detail how the various sensors will be processed and disseminated to the operator.

• Ensure financial responsibility with the ROC (see Section 9.4), or in the case of non-Global Agreement operators, complete an Argos Purchase Order.

9.2 - Application procedure

Argos programmes

A "programme" is a user-specific application of the Argos system, consisting of:

(a) Procuring the certified PTTs;

(b) Deploying those PTTs within a defined area, over a defined period of time;

(c) Receiving the PTT data from an Argos processing centre or a Local User Terminal (LUT).

Conditions for programme approval

Data collection and location must relate to the characteristics of the Earth and its natural phenomena by helping to better understand, evaluate, monitor or protect its natural resources.

Applications not directly concerned with this definition may, in some cases, be approved by the Argos OC provided that the application does not last for an extended period of time (normally less than one year), and does not conflict with satellite or ground system resources used for environmental purposes.

Approval priorities

The priorities for selecting new programmes when there is a risk of saturation of the satellite instruments are as follows.

(a) Programmes which require the unique capability of the Argos system and are devoted to environmental monitoring;

(b) Programmes devoted to environmental monitoring but which may not require the unique capability of the Argos system (included in this category are programmes which could be handled by geostationary satellite systems);

(c) Programmes consisting of data collection and location experiments beyond the scope of environmental monitoring (within the conditions for programme approval indicated above).

Programme application form

The submission of a new programme by a user is simply based on the completion of a form named the "Programme application form" (see Annex VII). The programme application form consists of the following information:

    (a) Identification of the programme director (applicant).

    (b) Description of the programme aims.

    (c) Scope of the programme (starting date, duration, area of interest).

    (d) PTT characteristics (number, type).

    (e) Brief definition of the requested processing to be undertaken by Service Argos.

If the approval is granted, Service Argos sends the user the following documents together with the notification of approval:

    (a) The Programme Review which provides the user (and PTT manufacturer) with the Argos ID number and the repetition period assigned to the PTT(s).

    (b) The document "technical file" for the user to define his data processing and access requirements.

    (c) The Argos tariff and a purchase order.

These three steps constitute the "admission" procedure. The user is reminded that he must make his own arrangements with his local authorities to obtain whatever license is required to operate the PTTs. The admission process takes about four weeks.

If the OC does not approve an applicant's programme, notification is sent to the user stating the reason.

See Annex V for references of Argos offices.

9.3 - Technical preparation

The preparation phase allows Service Argos the means to establish the support required for a newly-approved programme. This process is started by the user entering his requirements in a Technical File and sending it to Service Argos.

- Sensor data processing options (see Section 4.1),
- Location processing (see Section 4.2),
- On-line data access options (see Section 6),
- Off-line data access options (see Section 7).

If the data are requested for GTS distribution, the user must also submit a dedicated GTS Technical file to Service Argos (see Section 5).

9.4 - Financial agreement

The Argos system is operated on a cost-recovery basis with users contributing a fraction of the running costs proportional to the amount of the service required. Governments and other non-profit-making users may reduce their contribution by participating in the Argos Global Agreement as described below.

Argos Global Agreement

The Argos Global Agreement (also named "Joint Tariff Agreement") is prepared every year (normally in late October), at a meeting convened by the WMO and the IOC. Individual agreements are concluded between CLS or Service Argos Inc. and the participating countries. The agreement involves the payment of a fixed reduced cost covering all PTT usage up to a defined global maximum. All countries are encouraged to join the Global Agreement and take advantage of the preferential tariff arrangements. Countries are asked to notify CLS or Service Argos Inc. of their estimated participation level before 1 March of every year.

The contractual information below is valid for the 1995 contract and may be different in the following years. Please refer to the JTA annual session report published by WMO and IOC for actual conditions regarding a given year (e.g. conditions valid for 1995 are given in the final report of the fourteenth meeting on Argos Joint Tariff Agreement (La Jolla, 7-9 November 1994)).

Each country interested in joining the Global Agreement must designate a national co-ordinator, named the "Representative Organization for a Country or countries (ROC)". The main tasks of the ROC, in relation to CLS or Service Argos Inc., are to:

(a) Provide CLS or Service Argos Inc. with the list of programmes covered by the agreement and update this list as appropriate. Authorized programmes are those funded entirely by non-profit-making institutions (such as government agencies).

(b) Negotiate with CLS or Service Argos Inc. the minimum guaranteed Argos system utilization corresponding to authorized programmes, and pay for 70% of the total amount in advance;

Each programme authorized under this agreement must also comply with the general rules governing use of the system.

Under the Global Agreement, Service Argos performs the following categories of services:

(1)   Location determination or both location determination and data collection for PTTs with a repetition period equal to or less than 120 seconds, application of

calibration curves to the data when appropriate, access to the data and distribution of the data, and archiving for three months.

(1a) Same as (1) but subject to the limitation under LIMITED USE SERVICE.

(2) Data collection for PTT's with a repetition period greater than 200 seconds, application of calibration curves to the data when appropriate, access to the data and the distribution of the data, and archiving for three months.

(3) Same service as (1) except the locations and the data are not made available to the users unless they require the data and follow the conditions for back-up services.

(4) Same service as (2) except the data are not made available to the users unless they require the data and follow the conditions for back-up service.

Transmitting PTTs using the system but not requiring the above services are placed in "Inactive status". The user pays a fee to CLS or Service Argos Inc.

The basic accounting unit used is the "PTT-day" defined as one day of operation of a PTT such as Category 1, requiring complete standard service, with no more than six location fixes and 10 sensor data processing operations performed during that day. A PTT-year is 365 PTT-days.

For service Categories 2 to 4, a PTT not requiring the complete standard service contributes only a fraction of a PTT-day per day. The fraction is given in Table 13 below:

CONDITIONS FOR LIMITED USE SERVICE

This service is intended for those users whose programs which may operate effectively using a reduced number of data transmissions. PTTs under this service category are supposed to use a randomly initiated and regular duty cycle.
The following conditions must be met to qualify:

(1) Standard location or standard location and data processing (services) only apply.

(2) Platform can transmit no more than twenty four (24) hours in any 72-hour period.

(3) Users will be charged the standard data collection and location rate for actual PTT-days used up to a maximum of ten per month.

(4) All platforms in a single program must meet these conditions.

(5) Separate programme applications must be submitted.

CONDITIONS FOR BACK-UP SERVICE

(1) For PTTs covered by the "back-up service" the data are stored in a special data bank for 3 months, but will not be distributed to the user. All PTTs of this type will be counted at 2X/5 (category 3) or X/5 (category 4) of the corresponding tariff under the Global Agreement.

(2) Each user can require Service Argos to grant access to the active computer files during a specified period. Service Argos will perform the required file modifications. During the specified period, the PTTs will be counted at the standard tariff (category 1 or 2) in the Global Agreement from the first of the month in progress. Each operation involving a file modification will be charged directly to the user as indicated under "Limitations on PTT's", paragraph 1.

(3) Upon request, CLS/SERVICE ARGOS will provide magnetic tapes and/or printouts and/or floppy disks including the data from PTTs in the back-up mode for a specified period up to three months before the receipt of the order. For the specified period the PTTs will be counted at the standard tariff (category 1 or 2) in the Global Agreement.

(4) CLS/SERVICE ARGOS will begin required services only after receipt of a detailed letter or telex specifying the service and the period required and the program involved.

CONDITIONS FOR INACTIVE STATUS

This status is intended for those platforms that continue to transmit but for which the location or data collection are of no further use to the user or the community. The following conditions must be met to qualify:

(1) Platforms in Standard Service (category (1) or (2)) only apply.

(2) The platforms must have operated in category (1) or (2) for a minimum of 2 months.

(3) Data or location information cannot be retrieved nor can the platform revert to any category of service.

(4) It is intended that Location and/or data collection may not be computed using a Local User Terminal or other direct readout facility.

Table 13 - Summary of services provided by Service Argos under the Global Agreement

Processing by Service Argos	Category	Repetition Period	Location computed	Data collection and sensor processing	On-line data access	Data archiving	Tariff[1]
Standard	1	≤ 120 sec	YES	YES	YES	YES	X
	2	> 120 sec	NO	YES	YES	YES	X/2
Limited Use Service	1a	≤ 120 sec	YES	YES	YES	YES	*
Back Up	3	≤ 120 sec	YES	YES	NO	YES	2X/5
	4	> 120 sec	NO	YES	NO	YES	X/5
Inactive Status	5		NO	NO	NO	NO	X/6

[1] For example, the value of X valid for the 1995 contract is FF26000. Since this value may differ substancially from one year to the other, for actual conditions regarding a given year please refer to the JTA annual session report published by WMO and IOC.

* Users will be charged the standard data collection and location rate for actual PTT-days used up to a maximum of ten per month

The Service Argos accounting system records the number of PTT-days per country and sends quarterly reports to the ROC giving the accumulated number of PTT-days. The contribution to the running costs for one authorized PTT-year is determined during the last quarter of every year, at a meeting organized by the WMO and IOC. During the meeting, the countries' contributions are negotiated in parallel with the determination of the maximum global system utilization. For the period beginning 1 January, each ROC purchases for authorized users the negotiated guaranteed minimum of PTT-years in advance and for 12 months' service. On 31 December, the final count of PTT-years, and fractions thereof which were actually used will be determined. Additional contributions will be charged to the participating countries using more PTT-years than agreed.

Users operating programmes under the Global Agreement are charged directly by CLS or Service Argos Inc. for services not included within the agreement:

(a) Delivery of printouts or magnetic tapes.

(b) Modification in service required (change of processing or access options).

(c) Number of location fixes per day in excess of six.

(d) Number of sensor data processing operations per day in excess of ten.

These additional financial charges are determined as outlined in the Argos tariff document (see next sub-paragraph). These additional services must be ordered directly from Service Argos by the user operating the programme. The order consists of completing and forwarding a "Purchase Order" (PO) and renewing it once a year. For a newly-approved programme, the PO must be received prior to any PTT deployment. For an ongoing programme, the PO must be received before 1 January.

The tariff document is generally sent with the PO. Both documents are mailed to the users in charge of either:

(a) Newly approved programmes, together with the notification of approval;

(b) Ongoing programmes every year during the last quarter.

In case (a), the user must complete and mail the PO back to Service Argos prior to deploying any PTTs. In case (b), the user must complete and mail the PO back to Service Argos before 1 January. In both cases, one PO is always required every year to cover services up to 31 December.

Remark: There is no extra charge for using the GTS Sub-system.

ANNEX I: Terms of reference for the Data Buoy Co-operation Panel and its Technical Co-ordinator

The Data Buoy Co-operation Panel shall:

1.   Consider the expressed needs of the international meteorological and oceanographic communities for real-time or archival data from ocean data buoys on the high seas and request action from its members, Technical Co-ordinator or action groups to meet these needs;

2.   Co-ordinate activity on existing programmes so as to optimize the provision and timely receipt of good quality data from them;

3.   Propose, organize and implement through the coordination of national contributions, the expansion of existing programmes or the creation of new ones to supply such data;

4.   Support and organize as appropriate such action groups as may be necessary to implement the deployment of data gathering buoys to meet the express needs of operational oceanographic and meteorological communities;

5.   Encourage the initiation of national contributions to data buoy programmes from countries which do not make them;

6.   Promote the insertion of all available and appropriate buoy data into the Global Telecommunication System;

7.   Promote the exchange of information on data buoy activities and encourage the development and transfer of appropriate technology;

8.   Ensure that other bodies actively involved in buoy use are informed of the workings of the panel and encourage, as appropriate, their participation in the panel deliberations;

9.   Make and regularly review arrangements to secure the services of a Technical Co-ordinator with the terms of reference given below;

10.   Submit annually to the Executive Councils of the WMO and the IOC a report which shall include summaries of the existing and planned buoy deployments and data flow.

<u>Terms of reference for the Technical Co-ordinator of the</u>
<u>Data Buoy Co-operation Panel</u>

The Technical Co-ordinator of the Data Buoy Co-operation Panel shall:

1.   Under the direction of the Data Buoy Co-operation Panel take all possible steps within the competence of the panel to assist in the successful achievement of its aims;

2.   Assist in the development, implementation and management of quality control procedures for data buoy systems;

3.   Assist in setting up suitable arrangements for notifying the appropriate user communities of changes in the functional status of operational buoys;

4.   Assist in the standardization of buoy data formats, sensor accuracy, etc.;

5.   Assist when requested with the development of co-operative arrangements for buoy deployment;

6.   Assist in the clarification and resolution of issues between Service Argos and buoy operators;

7.   Assist in promoting the insertion of all available and appropriate buoy data into the Global Telecommunication System;

8.   Supply information about buoy developments and applications to the WMO and IOC Secretariats and assist the Data Buoy Co-operation Panel to promote an international dialogue between oceanographers and meteorologists;

9.   Co-ordinate and monitor the flow of buoy data into appropriate permanent archives.

ANNEX II: International identifier system for environmental data buoy stations

<u>Particulars of an identifier</u>

1. The international identifier system for environmental data buoy stations (commonly called international buoy identifier) was first adopted by Recommendation 8 (CBS-Ext.(76)). The primary objective of the system is to provide buoy stations with an identifying number similar to the "station index number" of land meteorological stations for operational and storage and retrieval purposes.

2. The symbolic form of the identifier is $A_1 b_w n_b n_b n_b$ and is used in FM 13-X SHIP and FM 18-X BUOY. Symbolic letters are as follows:

A_1 WMO Regional Association area in which buoy has been deployed
           1: Region I, Africa
           2: Region II, Asia
           3: Region III, South America
           4: Region IV, North and Central America
           5: Region V, South West Pacific
           6: Region VI, Europe
           7: Antarctic

b_w Sub-area belonging to the area indicated by A_1

$n_b n_b n_b$ Type and serial number of buoy.

3. Serial numbers to buoys within each maritime sub-area identified by a_1 and b_w shall be allocated from the series 000 up to 499 but in the case of drifting buoys and other mobile platforms, 500 shall be added to the original $n_b n_b n_b$ number.

Examples

14015 = No. 15 buoy, deployed in sub-area 4 in Region I, stationary
46673 = No. 173 buoy, deployed in sub-area 6 in Region IV, drifting

A chart showing the sea areas for allocation is attached (figure 8).

<u>Procedures for the use and allocation of identifiers</u>

4. The identifier may be allocated to fixed as well as drifting buoy stations, mobile ship stations and, in some cases, land-based remote stations. In the case of drifting buoys (and similarly other mobile platforms), a buoy will retain the original identifier applicable to the WMO Region and sub-area in which it was set adrift. As adopted by Recommendation 5 (CBS-Ext.(85)), stations at sea located on a drifting rig or oil- or gas-production platform shall also carry an identifier number. In the case of such "semi-mobile" platforms, a new number will be required if the platform changes its geographical location from one area to another.

5. The allocation of identifier numbers is carried out by the WMO Secretariat, as necessary, in consultation with the IOC Secretariat.

(a) On request by interested countries, through the Permanent Representatives of Members of WMO or the national focal points for drifting buoy programmes, the WMO Secretariat allocates them a block or blocks of identifier numbers. When submitting requests, the geographical locations and nature of platforms should be specified (the position of initial deployment in the case of drifting buoys);

(b) Countries register with the WMO Secretariat platforms deployed together with identifier numbers actually assigned to them. It is also recommended that parameters measured and transmitted be notified. Stations thus registered will be included in the monthly letter on the operation of the World Weather Watch (WWW) and marine meteorological services.

6. A number allocated to a particular country may effectively be used twice by that country only, directly as allocated for a fixed platform and with the addition of 500 for a mobile platform.

Figure 8 - sea areas (A₁bₓ) for use in assigning buoy identifiers.

A₁: WMO Regional Association area where buoy is deployed (1-Region I, 2-Region II, etc.).

bₓ: Sub-area belonging to area indicated by A₁.
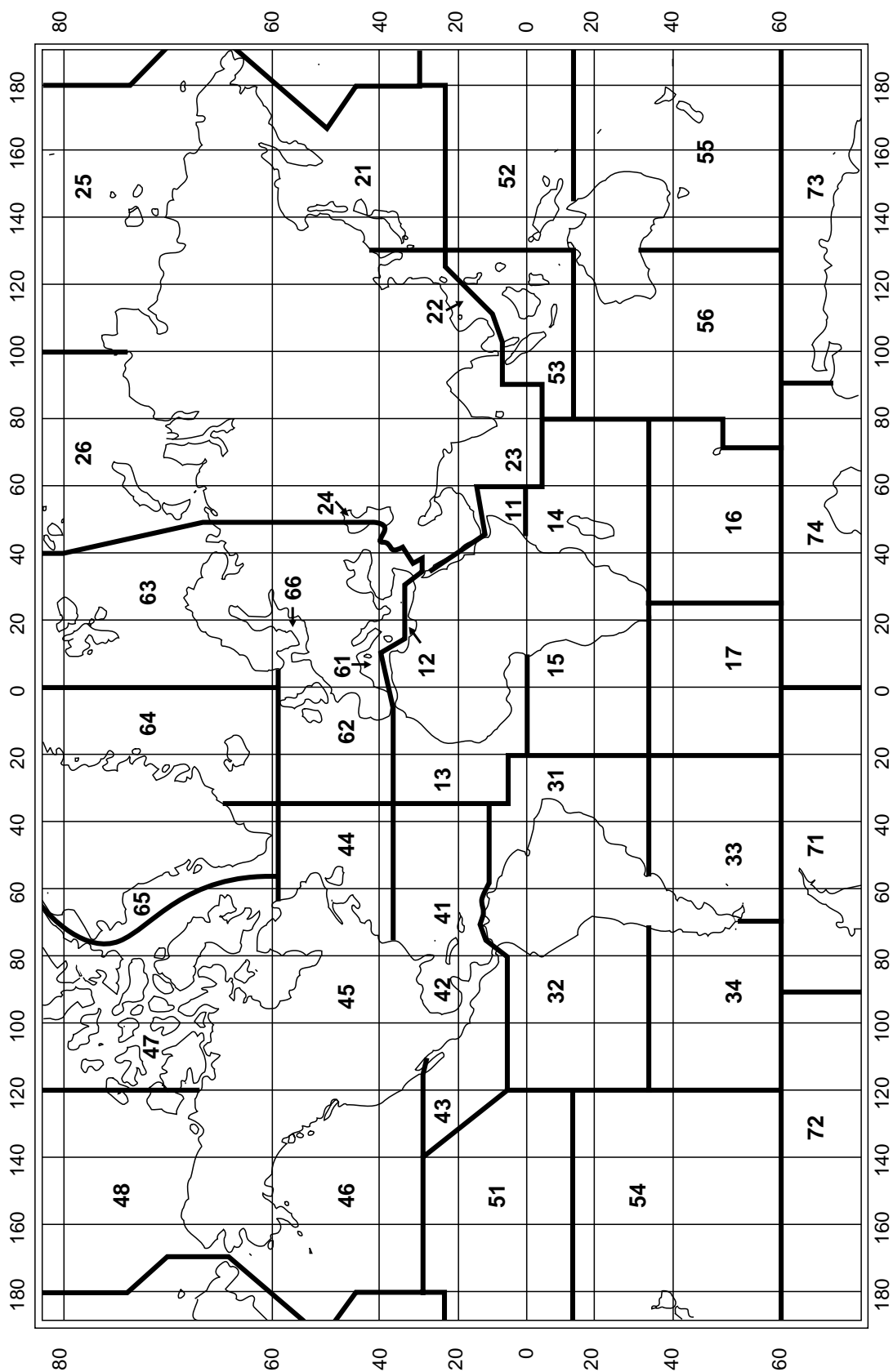
ANNEX III: GTS codes used with the Argos system for GTS distribution

Note: This is neither an official description of WMO GTS code forms, nor a detailed one; it is rather written taking into consideration how these code forms can be used with the Argos system. For formal WMO regulations and details, see the WMO Manual on Codes, Volume 1, International Codes, WMO N° 306. Only groups used with the Argos system appear in the code descriptions below.

In the following code descriptions,

- (i)   Fields in **bold** are code fields
- (ii) Fields in parenthesis () are optional
- (iii) Underlined fields are constant fields or constant parts of the message (e.g. 888)
- (iv) Fields in brackets {} are exclusive

III.1) **The DRIFTER code** (WMO code form FM 18-IX Ext. DRIFTER)

Report of a drifting buoy observation (and moored buoy).
Was replaced with the BUOY code on the 2 November 1994.

Section 0 is mandatory, all other sections are optional.

Section 0:	$\underline{\textbf{ZZXX}}$		$\textbf{A}_1\textbf{b}_w\textbf{n}_b\textbf{n}_b\textbf{n}_b$ $\textbf{YYMMJ}$	$\textbf{GGggi}_w$
			$\textbf{Q}_c\textbf{L}_a\textbf{L}_a\textbf{L}_a\textbf{L}_a\textbf{L}_a$	$\textbf{L}_o\textbf{L}_o\textbf{L}_o\textbf{L}_o\textbf{L}_o\textbf{L}_o$

Section 1:	$\underline{\textbf{0}}\textbf{ddff}$	$(\underline{\textbf{1}}\textbf{s}_n\textbf{TTT})$	$(\underline{\textbf{2}}\textbf{PPPP})$	$(\underline{\textbf{3}}\textbf{appp})$

Section 2:	$\underline{\textbf{222}}$	$(\underline{\textbf{0}}\textbf{S}_n\textbf{T}_w\textbf{T}_w\textbf{T}_w)$	$(\underline{\textbf{1}}\textbf{P}_{wa}\textbf{P}_{wa}\textbf{H}_{wa}\textbf{H}_{wa})$	
		$(\underline{\textbf{20}}\textbf{P}_{wa}\textbf{P}_{wa}\textbf{P}_{wa})$	$(\underline{\textbf{21}}\textbf{H}_{wa}\textbf{H}_{wa}\textbf{H}_{wa})$	

Section 3:	$\underline{\textbf{333}}$			
	$\underline{\textbf{8887}}\textbf{k}_2$	$(\underline{\textbf{2}}\textbf{z}_o\textbf{z}_o\textbf{z}_o\textbf{z}_o)$	$(\underline{\textbf{3}}\textbf{T}_o\textbf{T}_o\textbf{T}_o\textbf{T}_o)$	$(\underline{\textbf{4}}\textbf{S}_o\textbf{S}_o\textbf{S}_o\textbf{S}_o)$
		$\cdots\cdots$		
		$(\underline{\textbf{2}}\textbf{z}_n\textbf{z}_n\textbf{z}_n\textbf{z}_n)$	$(\underline{\textbf{3}}\textbf{T}_n\textbf{T}_n\textbf{T}_n\textbf{T}_n)$	$(\underline{\textbf{4}}\textbf{S}_n\textbf{S}_n\textbf{S}_n\textbf{S}_n)$
	$\underline{\textbf{66}}\textbf{k}_6\underline{\textbf{9}}\textbf{k}_3$	$(\underline{\textbf{2}}\textbf{z}_o\textbf{z}_o\textbf{z}_o\textbf{z}_o)$	$(\textbf{d}_o\textbf{d}_o\textbf{c}_o\textbf{c}_o\textbf{c}_o)$	
		$\cdots\cdots$		
		$(\underline{\textbf{2}}\textbf{z}_n\textbf{z}_n\textbf{z}_n\textbf{z}_n)$	$(\textbf{d}_n\textbf{d}_n\textbf{c}_n\textbf{c}_n\textbf{c}_n)$	

Section 4:	$\underline{\textbf{444}}$	$(\underline{\textbf{20}}\textbf{Q}_L\underline{\textbf{/}})$	$(\textbf{H}_L\underline{\textbf{////}})$	
		$(\underline{\textbf{8}}\textbf{V}_i\textbf{V}_i\textbf{V}_i\textbf{V}_i)$	$(\underline{\textbf{90}}\textbf{Z}_d\textbf{Z}_d\textbf{Z}_d)$	

Brief description of groups for DRIFTER:

$A_1b_wn_bn_bn_b$	WMO Identification number
YYMMJ	Day of the month, Month, Year
$GGggi_w$	Hour, Minutes, Indicator for wind units (1=m/s, 4=knots)
$Q_cL_aL_aL_aL_a$	Quadrant of the globe (1:NE,3:SE,5:SW,7:NW, Latitude (1/1000 degrees)
$L_oL_oL_oL_oL_o$	Longitude (1/1000 degrees)
ddff	Wind Direction (10 degrees), Wind Speed (m/s or Knots depending upon iw)
s_nTTT	Air Temperature (1/10 C), sn=1 if <0, sn=0 if >0
PPPP	Air Pressure (1/10 hPa)
appp	Characteristic of air pressure tendency, air pressure tendency in the last 3 hours (1/10 hPa/3H). **a** is coded as follows: 2=pressure is increasing; 4=pressure is steady; 7=pressure is decreasing.
$S_nT_wT_wT_w$	Sea Surface Temperature (1/10 C), sn=1 if <0, sn=0 if >0
$P_{wa}P_{wa}$	Period of waves
$H_{wa}H_{wa}$	Height of waves
$P_{wa}P_{wa}P_{wa}$	Period of waves (1/10 S, accurate)
$H_{wa}H_{wa}H_{wa}$	Height of waves (1/10 M, accurate)
k_2	Indicator for salinity
$z_nz_nz_nz_n$	Depth (M)
$T_nT_nT_nT_n$	Water Temperature at depth (C, +5000 if <0)
$S_nS_nS_nS_n$	Water Salinity at Depth (ppm)
k_6	Method for removing ship's velocity and motion from current measurement
k_3	Duration and time of current measurement
$z_nz_nz_nz_n$	Depth (M)
$d_nd_nc_nc_nc_n$	Direction (10 Deg), and Speed (cm/s) of Marine Currents at Depth
Q_L	Quality of Location (0=OK, 1=Latest known location)
H_L	Number of hours between Location time and Observation time (GGgg)
$V_iV_iV_iV_i$	Housekeeping Parameter number i (up to 3 parameters)
$Z_dZ_dZ_d$	Depth of the drogue (M) coded if requested by the Principal Investigator.

Example of DRIFTER message:

ZZXX
12345 29013 0756/ 761567 022345
0//// 20145=

Platform WMO 12345 the 29-JAN-1993 at 7:56 UTC, 61.567N, 22.345W, Air Pressure=1014.5 hPa.

III.1) BUOY code (WMO code form FM 18-X BUOY)

Report of a drifting or moored buoy observation.
Replaced DRIFTER on the 2 November 1994.

Section 0 is mandatory, all other sections are optional.

Section 0:   **ZZYY** $A_1b_wn_bn_bn_b$ **YYMMJ**   **GGggi$_w$**
              $Q_cL_aL_aL_aL_aL_a$ $L_oL_oL_oL_oL_oL_o$ (**6**Q_lQ_t//)

Section 1:   **111**Q_dQ_x **0**ddff   (**1**s_nTTT)
              {(**2**$s_nT_dT_dT_d$) or (**29**UUU)}
              (**3**$P_oP_oP_oP_o$)   (**4**PPPP)   (**5**appp)

Section 2:   **222**Q_dQ_x (**0**$S_nT_wT_wT_w$)   (**1**$P_{wa}P_{wa}H_{wa}H_{wa}$)
              (**20**$P_{wa}P_{wa}P_{wa}$)   (**21**$H_{wa}H_{wa}H_{wa}$)

Section 3:   **333**$Q_{d1}Q_{d2}$
              8887k_2 (**2**$z_oz_oz_oz_o$)   (**3**$T_oT_oT_oT_o$)   (**4**$S_oS_oS_oS_o$)
                                . . . .
                          (**2**$z_nz_nz_nz_n$)   (**3**$T_nT_nT_nT_n$)   (**4**$S_nS_nS_nS_n$)
              66k_6**9**k_3 (**2**$z_oz_oz_oz_o$)   ($d_od_oc_oc_oc_o$)
                                . . . .
                          (**2**$z_nz_nz_nz_n$)   ($d_nd_nc_nc_nc_n$)

Section 4:   **444**   (**1**$Q_pQ_2Q_{TW}Q_4$)   (**2**Q_NQ_L//)
              {($Q_cL_aL_aL_aL_aL_a$ $L_oL_oL_oL_oL_oL_o$) or (YYMMJ GGgg/)}

              (**7**$V_BV_Bd_Bd_B$)   (**8**$V_iV_iV_iV_i$)   (**9**$i_dZ_dZ_dZ_d$)

Brief description of the groups for BUOY:

$A_1b_wn_bn_bn_b$	WMO Identification number
YYMMJ	Day in the month, Month, Year
GGggi$_w$	Hour, Minutes, Indicator for wind units (1=m/s, 4=knots)
$Q_cL_aL_aL_aL_aL_a$	Quadrant of the globe (1:NE,3:SE,5:SW,7:NW, Latitude (1/1000 degrees)
$L_oL_oL_oL_oL_oL_o$	Longitude (1/1000 degrees)
Q_l	Quality control indicator for the location fix. 0=not checked, 1=good, 2=inconsistent, 3=doubtful, 4=wrong, 5=data changed.
Q_t	Quality control indicator for the time of observation. 0=not checked, 1=good, 2=inconsistent, 3=doubtful, 4=wrong, 5=data changed.
Q_d	Quality control indicator for the section. 0=not checked, 1=good, 2=inconsistent, 3=doubtful, 4=wrong, 5=data changed.
Q_x	Number of the only group of the section whose Quality Control indicator is not 1. Otherwise this group is coded 9.
ddff	Wind Direction (10 degrees), Wind Speed (m/s or Knots depending upon iw)
s_nTTT	Air Temperature (1/10 C), sn=1 if <0, sn=0 if >0
$s_nT_dT_dT_d$	Dew-Point Temperature (1/10 C), sn=1 if <0, sn=0 if >0

UUU	Air Humidity (%)
$P_oP_oP_oP_o$	Air Pressure at station level (1/10 hPa)
PPPP	Air Pressure reduced at sea level (1/10 hPa)
appp	Characteristic of air pressure tendency, air pressure tendency in the last 3 hours (1/10 hPa/3H). **a** is coded as follows: 2=pressure is increasing; 4=pressure is steady; 7=pressure is decreasing.
$S_nT_wT_wT_w$	Sea Surface Temperature (1/10 C), sn=1 if <0, sn=0 if >0
$P_{wa}P_{wa}$	Period of waves
$H_{wa}H_{wa}$	Height of waves
$P_{wa}P_{wa}P_{wa}$	Period of waves (1/10 s, accurate)
$H_{wa}H_{wa}H_{wa}$	Height of waves (1/10 m, accurate)
Q_{d1}	Quality control indicator for temperature salinity profile. 0=not checked, 1=good, 2=inconsistent, 3=doubtful, 4=wrong, 5=data changed.
Q_{d2}	Quality control indicator for current speed and direction profile. 0=not checked, 1=good, 2=inconsistent, 3=doubtful, 4=wrong, 5=data changed.
k_2	Indicator for salinity
$z_nz_nz_nz_n$	Depth (m)
$T_nT_nT_nT_n$	Water Temperature at depth (C, +5000 if <0)
$S_nS_nS_nS_n$	Water Salinity at Depth (ppm)
k_6	Method for removing ship's velocity and motion from current measurement
k_3	Duration and time of current measurement
$z_nz_nz_nz_n$	Depth (m)
$d_nd_nc_nc_nc_n$	Direction (10 Deg), and Speed (cm/s) of Marine Currents at Depth
Q_p	Quality control indicator for Air Pressure. 0=good, 1=bad.
Q_2	Quality control indicator for the first housekeeping parameter. 0=good, 1=bad.
Q_{TW}	Quality control indicator for the water-surface temperature measurement. 0=good, 1=bad.
Q_4	Quality control indicator of the air temperature. 0=good, 1=bad.
Q_N	Quality of the satellite transmission. 0=good, 1=doubtful.
Q_L	Quality of Location (0=OK, 1=Latest known location). If the value is 1, then the date and time of the location fix is given by the groups YYMMJ GGgg of section 4.
$V_BV_Bd_Bd_B$	Speed and direction of the buoy at the last known position. Speed V_BV_B is given in cm/s, and Direction d_Bd_B is given in tens of degrees.
$V_iV_iV_iV_i$	Housekeeping Parameter number i (up to 3 parameters)
$Z_dZ_dZ_d$	Depth of the drogue (m) coded if requested by the Principal Investigator.

Example of BUOY message:

ZZYY
12345 29013 0756/ 761567 022345 611//
11119 0//// 40145=

Platform WMO 12345 on 29 January 1993 at 7:56 UTC, 61.567N, 22.345W (good time and good location), Good Air Pressure=1014.5 hPa.

III.2) <u>SYNOP code</u> (WMO code forms FM 12-X SYNOP):

Report of surface observation from a land station. Used for reporting synoptic surface observations from a land station, manned or automatic.

Section 0 and 1 are mandatory, Sections 2 and 3 are optional.

Section 0:

$$\underline{\text{AAXX}} \quad \text{YYGG}i_w$$
$$\text{IIiii}$$

Section 1:

$$\{ \quad (\underline{2}s_n T_d T_d T_d) \}$$
$$i_R i_x / VV \quad /ddff \quad (\underline{00}fff) \quad (\underline{1}s_n TTT) \quad \{ \quad \text{or} \quad \}$$
$$\{ \quad (\underline{29}UUU) \quad \}$$

$$\{ \quad (\underline{4}PPPP)\}$$
$$(\underline{3}P_o P_o P_o P_o) \{ \quad \text{or} \quad \} \quad (\underline{5}appp) \ (\underline{6}RRRt_R)$$
$$\{ \quad (\underline{4}a_3 hhh) \quad \}$$

$$(\underline{9}GGgg)$$

Section 2:

$$\underline{22200} \quad (\underline{0}s_s T_w T_w T_w)(\underline{1}P_{wa} P_{wa} H_{wa} H_{wa}) \quad (\underline{2}P_w P_w H_w H_w) \quad (\underline{70}H_{wa} H_{wa} H_{wa})$$

$$(\underline{8}s_w T_b T_b T_b)$$

Section 3:

$$\underline{333} \ (\underline{1}s_n T_x T_x T_x) \ (\underline{2}s_n T_n T_n T_n) \quad (\underline{4}/sss)$$

$$(\underline{907}tt \quad \underline{911}ff \quad (\underline{00}fff))$$

Brief description of groups for SYNOP:

YYGGi_w	Day in the month, Hour, Indicator for wind units (1=m/s, 4=knots)
IIiii	WMO Identification number
i_R	Indicator for precipitation data
i_x	Type of station (3:Manned, 6:Automatic)
VV	Horizontal visibility
ddff	Wind Direction (10 degrees), Wind Speed (m/s or Knots depending upon iw)
fff	Wind speed in units indicated by iw
s_nTTT	Air Temperature (1/10 C), sn=1 if <0, sn=0 if >0
$s_nT_dT_dT_d$	Dew-Point Temperature (1/10 C), sn=1 if <0, sn=0 if >0
UUU	Air Humidity (%)
PPPP	Air Pressure at mean sea level (1/10 hPa)
$P_oP_oP_oP_o$	Air Pressure at station level (1/10 hPa)
appp	Characteristic of air pressure tendency, air pressure tendency in the last 3 hours (1/10 hPa/3H). Refer to table number 200 of the WMO Manual on Codes, Volume I, WMO No 306, Part D, for the possible values of **a**.
$RRRt_R$	Precipitations, period for precipitations. Refer to WMO Manual on Codes for details.
a_3hhh	Isobaric surface (1:1000 hPa, 5:500, 7:700, 8:850), Geopotential (M Modulo 1000)
GGgg	Hour and minutes of time of observation if asynoptic time.
s_s	Sign and Type of Sea Surface Temperature measurement :

Code figure	Sign	Type of measurement
0	SST>0	Intake
1	SST<0	Intake
2	SST>0	Bucket
3	SST<0	Bucket
4	SST>0	Hull Contact Sensor
5	SST<0	Hull Contact Sensor
6	SST>0	Other
7	SST<0	Other

$T_wT_wT_w$	Sea Surface Temperature (1/10 C), sign is given by **s_s**
$P_{wa}P_{wa}$	Period of waves
$H_{wa}H_{wa}$	Height of waves
P_wP_w	Period of wind waves
H_wH_w	Height of wind waves
$H_{wa}H_{wa}H_{wa}$	Height of waves (1/10 m, accurate)
s_w	Sign and Type of Wet Bulb Temperature measurement

Code figure	Sign	Type of measurement
0	SST>=0	Measured wet bulb temperature
1	SST<0	Measured wet bulb temperature
2	/	Ice bulb measured wet bulb temperature
3-4	/	Not used
5	SST>=0	Computed wet bulb temperature
6	SST<0	Computed wet bulb temperature
7	/	Ice bulb computed wet bulb temperature

$T_bT_bT_b$	Absolute value of Wet Bulb Temperature Measurement in 1/10 of Celsius
$s_nT_xT_xT_x$	Maximal Temperature in the last 24 hours (1/10 C), sn=1 if <0, sn=0 if >0
$s_nT_nT_nT_n$	Minimal Temperature in the last 24 hours (1/10 C), sn=1 if <0, sn=0 if >0
sss	Total depth of snow (cm)
tt	Period of reference for wind gust ending at the time of observation (WMO Table 4077): 00= at the observation, 10=1 hour, 30=3 hours, 69=unknown.
ff	Wind Gust (m/s or Knots depending upon **i_w**)
fff	Wind Gust in units indicated by **i_w** if > 99 units.

Example of SYNOP message:

AAXX 29061
07510 46/// /0723 10125=

Automatic Station WMO 07510 on 29 January 1993 at 06:00 UTC, Wind Direction =
70 Degrees, Wind Speed = 23 m/s, Air Temperature = 12.5 Celsius.

III.3) <u>SHIP code</u> (WMO code form FM 13-X SHIP):

Report of surface observation from a sea station. Used for reporting synoptic surface observations from a sea station, manned or automatic.

Section 0 and 1 are mandatory, Sections 2 and 3 are optional.

Section 0:

$\underline{\textbf{BBXX}}$
$\{ \quad \textbf{D} \dots \textbf{D} \quad \}$
$\{ \quad \text{or} \quad \} \quad \textbf{YYGGi}_w \quad \underline{\textbf{99}}\textbf{L}_a\textbf{L}_a\textbf{L}_a \quad \textbf{Q}_c\textbf{L}_o\textbf{L}_o\textbf{L}_o\textbf{L}_o$
$\{ \quad \textbf{A}_1\textbf{b}_w\textbf{n}_b\textbf{n}_b\textbf{n}_b \quad \}$

Section 1:

$$\{ \quad (\underline{\textbf{2}}\textbf{s}_n\textbf{T}_d\textbf{T}_d\textbf{T}_d) \quad \}$$
$\textbf{i}_R\textbf{i}_x\underline{\textbf{/VV}} \quad \underline{\textbf{/ddff}} \quad (\underline{\textbf{00}}\textbf{fff}) \quad (\underline{\textbf{1}}\textbf{s}_n\textbf{TTT}) \quad \{ \quad \text{or} \quad \}$
$$\{ \quad (\underline{\textbf{29}}\textbf{UUU}) \quad \}$$

$$\{ \quad (\underline{\textbf{4}}\textbf{PPPP}) \}$$
$(\underline{\textbf{3}}\textbf{P}_o\textbf{P}_o\textbf{P}_o\textbf{P}_o) \quad \{ \quad \text{or} \quad \} \quad (\underline{\textbf{5}}\textbf{appp}) \ (\underline{\textbf{6}}\textbf{RRRt}_R)$
$$\{ \quad (\underline{\textbf{4}}\textbf{a}_3\textbf{hhh}) \quad \}$$

$(\underline{\textbf{9}}\textbf{GGgg})$

Section 2:

$\underline{\textbf{222//}} \quad (\underline{\textbf{0}}\textbf{s}_s\textbf{T}_w\textbf{T}_w\textbf{T}_w)(\underline{\textbf{1}}\textbf{P}_{wa}\textbf{P}_{wa}\textbf{H}_{wa}\textbf{H}_{wa}) \quad (\underline{\textbf{2}}\textbf{P}_w\textbf{P}_w\textbf{H}_w\textbf{H}_w) \quad (\underline{\textbf{70}}\textbf{H}_{wa}\textbf{H}_{wa}\textbf{H}_{wa})$

$(\underline{\textbf{8}}\textbf{s}_w\textbf{T}_b\textbf{T}_b\textbf{T}_b)$

Section 3:

$\underline{\textbf{333}} \ (\underline{\textbf{1}}\textbf{s}_n\textbf{T}_x\textbf{T}_x\textbf{T}_x) \ (\underline{\textbf{2}}\textbf{s}_n\textbf{T}_n\textbf{T}_n\textbf{T}_n)$

$(\underline{\textbf{907}}\textbf{tt} \ \underline{\textbf{911}}\textbf{ff} \ (\underline{\textbf{00}}\textbf{fff}))$

Brief description of the groups for SHIP:

D ... D	Ship's call sign
A$_1$b$_w$n$_b$n$_b$n$_b$	WMO Identification number
YYGGi$_w$	Day in the month, Hour, Indicator for wind units (1=m/s, 4=knots)
L$_a$L$_a$L$_a$	Latitude (1/10 degrees)
Q$_c$L$_o$L$_o$L$_o$L$_o$	Quadrant of the globe (1:NE,3:SE,5:SW,7:NW, Longitude (1/10 degrees)
IIiii	WMO Identification number
i$_R$	Indicator for precipitation data
i$_x$	Type of station (3:Manned, 6:Automatic)
VV	Horizontal visibility
ddff	Wind Direction (10 degrees), Wind Speed (m/s or Knots depending upon iw)
fff	Wind speed in units indicated by iw
s$_n$TTT	Air Temperature (1/10 C), sn=1 if <0, sn=0 if >0
s$_n$T$_d$T$_d$T$_d$	Dew-Point Temperature (1/10 C), sn=1 if <0, sn=0 if >0
UUU	Air Humidity (%)
PPPP	Air Pressure at mean sea level (1/10 hPa)
P$_o$P$_o$P$_o$P$_o$	Air Pressure at station level (1/10 hPa)
appp	Characteristic of air pressure tendency, and air pressure tendency in the last 3 hours (1/10 hPa/3H). Refer to the table number 200 of the WMO Manual on Codes, Volume I, WMO No 306, Part D, for the possible values of **a**.
RRRt$_R$	Precipitations, period for precipitations. refer to the WMO Manual on Codes for details.
a$_3$hhh	Isobaric surface (1:1000 hPa, 5:500, 7:700, 8:850), Geopotential (M Modulo 1000)
GGgg	Hour and minutes of time of observation if asynoptic time.
s$_s$	Sign and Type of Sea Surface Temperature measurement :

Code figure	Sign	Type of measurement
0	SST>0	Intake
1	SST<0	Intake
2	SST>0	Bucket
3	SST<0	Bucket
4	SST>0	Hull Contact Sensor
5	SST<0	Hull Contact Sensor
6	SST>0	Other
7	SST<0	Other

T$_w$T$_w$T$_w$	Absolute value of Sea Surface Temperature (1/10 C)
P$_{wa}$P$_{wa}$	Period of waves
H$_{wa}$H$_{wa}$	Height of waves
P$_w$P$_w$	Period of wind waves
H$_w$H$_w$	Height of wind waves
H$_{wa}$H$_{wa}$H$_{wa}$	Height of waves (1/10 m, accurate)
s$_w$	Sign and Type of Wet Bulb Temperature measurement

Code figure	Sign	Type of measurement
0	SST>=0	Measured wet bulb temperature
1	SST<0	Measured wet bulb temperature
2	/	Ice bulb measured wet bulb temperature
3-4	/	Not used
5	SST>=0	Computed wet bulb temperature
6	SST<0	Computed wet bulb temperature
7	/	Ice bulb computed wet bulb temperature

T$_b$T$_b$T$_b$	Absolute value of Wet Bulb Temperature Measurement in 1/10 of Celsius
s$_n$T$_x$T$_x$T$_x$	Maximal Temperature in the last 24 hours (1/10 C), sn=1 if <0, sn=0 if >0
s$_n$T$_n$T$_n$T$_n$	Minimal Temperature in the last 24 hours (1/10 C), sn=1 if <0, sn=0 if >0
tt	Period of reference for wind gust ending at the time of observation (WMO Table 4077): 00=at the observation, 10=1 hour, 30=3 hours, 69=unknown.
ff	Wind Gust (M/S or Knots depending upon **i$_w$**)
fff	Wind Gust in units indicated by **i$_w$** if > 99 units.

Example of SHIP message:

BBXX
12345 29061 99213 70432
46/// /0723 10125=

Automatic Marine station WMO 12345 on 29 January 1993 at 06:00 UTC, Latitude = 21.3N, Longitude = 43.2W, Wind Direction = 70 Degrees, Wind Speed = 23 m/s, Air Temperature = 12.5 Celsius.

III.4) BATHY code (WMO code form FM 63-X Ext. BATHY):

Report of bathythermal observation.

Section 1 and 4 are mandatory, Sections 2 and 3 are optional.

Section 1:   **JJXX**
          YYMMJ   **GGgg/** $Q_cL_aL_aL_aL_a$ $L_oL_oL_oL_oL_o$
          ($i_u$ddff)   **(4s_nTTT)**

Section 2:   **8888k_1** $I_xI_xI_xX_RX_R$
                 ($z_oz_oT_oT_oT_o$)   ($z_1z_1T_1T_1T_1$) **...** ($z_nz_nT_nT_nT_n$)
                 (**999**zz   ($z_1z_1T_1T_1T_1$) **...** ($z_nz_nT_nT_nT_n$))

Section 3:   **66666**   ($k_5D_cD_cV_cV_c$)

Section 4:   {   **D .... D**   }
          {   or   }
          {**99999** $A_1b_wn_bn_bn_b$ }

Brief description of the groups for BATHY:

YYMMJ	Day in the month, month, year
GGgg	Hour, Minutes
$Q_cL_aL_aL_aL_a$	Quadrant of the globe (1:NE,3:SE,5:SW,7:NW, Latitude (degrees, minutes)
$L_oL_oL_oL_oL_o$	Longitude (degrees, minutes)
$i_u$ddff	Units used for wind speed, wind direction (10 Deg), wind speed
s_n**TTT**	Air temperature (1/10 C), sn=1 if <0, sn=0 if >0
k_1	Indicator for digitization
$I_xI_xI_x$	Instrument type for XBT with fall rate equation coefficients (see table 1770 from WMO Manual on codes (No. 306), Volume-I, part A)
X_RX_R	Recorder types (see table 4770 from WMO Manual on codes (No. 306), Volume-I, part A)
$z_nz_nT_nT_nT_n$	Depth (m modulo 100), Water Temperature
zz	Depth (100 m)
k_5	Indicator for the method of current measurements
$D_cD_cV_cV_c$	Direction of Surface Currents (10 Deg), Speed of Surface Currents (Knots)
D ... D	Ship's call sign
$A_1b_wn_bn_bn_b$	WMO Identification Number

Example of BATHY message:

JJXX
29013 0600/ 72122 04352
00723 40125
88887 04222 00124 10082
99901 50022
99999 12345=

Marine station WMO 12345 on 29 January 1993 at 06:00 UTC, Latitude = 21 deg. 22 min. North, Longitude = 43 deg. 52 min. West, Wind Direction = 70 Degrees, Wind

Speed = 23 m/s, Air Temperature = 12.5 Celsius, Temperatures at selected depths:
Surface:12.4 C, 10 meters: 8.2 C, 150 meters: 2.2 C.

D.5) <u>TESAC code</u> (WMO code form FM 64-IX TESAC):

Temperature, salinity and current report from a sea station. Section 1 and 5 are mandatory, sections 2, 3, and 4 are optional.

Section 1:   <u>**KKXX**</u>
               YYMMJ   **GGgg/** $Q_cL_aL_aL_aL_a$ $L_oL_oL_oL_oL_o$
                                  ($i_u$ddff)   **(4s_nTTT)**

Section 2:   <u>**888k_1k_2**</u>   **(2$z_oz_oz_oz_o$)**   **(3$T_oT_oT_oT_o$)**   **(4$S_oS_oS_oS_o$)**
                                       (2$z_1z_1z_1z_1$)   **(3$T_1T_1T_1T_1$)**   **(4$S_1S_1S_1S_1$)**
                                       . . .   **. . .**   **. . .**
                                       (2$z_nz_nz_nz_n$)   **(3$T_nT_nT_nT_n$)**   **(4$S_nS_nS_nS_n$)**

Section 3:   **(<u>66$k_6k_4k_3$</u>**   **(2$z_oz_oz_oz_o$)**   **($d_od_oc_oc_oc_o$)**
                                          (2$z_1z_1z_1z_1$)   **($d_1d_1c_1c_1c_1$)**
                                          . . .   **. . .**
                                          (2$z_nz_nz_nz_n$)   **($d_nd_nc_nc_nc_n$)**

Section 4:   (This section is not used with the Argos system)

Section 5:   **{   D .... D   }**
               {   or   }
               {   <u>99999</u> $A_1b_wn_bn_bn_b$ }

<u>Brief description of the groups</u>:

YYMMJ	Day in the month, Month, Year
GGgg	Hour, Minutes
$Q_cL_aL_aL_aL_a$	Quadrant of the globe (1:NE,3:SE,5:SW,7:NW, Latitude (Degrees, Minutes)
$L_oL_oL_oL_oL_o$	Longitude (Degrees, Minutes)
$i_u$ddff	Units used for wind speed, wind direction (10 Deg), wind speed
s_nTTT	Air Temperature (1/10 C), sn=1 if <0, sn=0 if >0
k_1	Indicator for digitization
k_2	Indicator for salinity
$z_nz_nz_nz_n$	Depth (m)
$T_nT_nT_nT_n$	Water Temperature at depth (C, +5000 if <0)
$S_nS_nS_nS_n$	Water Salinity at Depth (ppm)
k_3	Duration and time of current measurement
k_4	Period of current measurement
k_6	Method for removing ship's velocity and motion from current measurement
$d_nd_nc_nc_nc_n$	Direction (10 Deg), and Speed (cm/s) of Marine Currents at Depth
D ... D	Ship's call sign
$A_1b_wn_bn_bn_b$	WMO Identification number

<u>Example of TESAC message</u>:
KKXX
29013 0600/ 72122 04352 00723 40125
88871 20000 30124 20010 30082 40035 20150 30022
99999 12345=

Marine station WMO 12345 on 29 January 1993 at 06:00 UTC, Latitude = 21 deg. 22 min. North, Longitude = 43 deg. 52 min. West, Wind Direction = 70 Degrees, Wind

Speed = 23 m/s, Air Temperature = 12.5 Celsius, Temperatures at selected depths: Surface:12.4 C, 10 meters: 8.2 C, 150 meters: 2.2 C. Salinity at 10 meters: 35 ppm.

D.6) <u>HYDRA code</u> (WMO code form FM 67-VI HYDRA):

Report of hydrological observation from a hydrological station.

Section 1 is mandatory, other sections are optional.

Section 1:   **<u>HHXX</u>**   **YYGG**   **(<u>000</u>AC$_i$)**   **BBi$_H$i$_H$i$_H$**

Section 2:   **<u>22</u>**   **(/H$_s$H$_s$H$_s$H$_s$)**

Section 3:   **<u>33</u>**   **(/QQQe$_Q$)**

Section 4:   **<u>44</u>**   **(t$_p$RRRR)**   **(. . .)**   **(. . .)**

Section 5:   **<u>55</u>**   **(ts$_n$T$_t$T$_t$T$_t$)**   **(. . .)**   **(. . .)**

Section 6:   **<u>66</u>**   **(DDDss)**

<u>Brief description of the groups:</u>

YYGG	Day in the month, Synoptic hours
AC$_i$	WMO Regional association area, Country
BBi$_H$i$_H$i$_H$	Basin, National hydrological observing station identifier
H$_s$H$_s$H$_s$H$_s$	Stage (cm)
QQQe$_Q$	Discharge (first 3 digits of discharge in dm^3/s, exponent for QQQ)
t$_p$RRRR	Period for precipitations, Total amount of precipitations
ts$_n$T$_t$T$_t$T$_t$	Nature of the Temperature reading, Temperature of the element indicated by t (1/10 C), sn=1 if <0, sn=0 if >0
DDDss	Ice thickness (cm), Depth of snow on ice (cm)

<u>Example of HYDRA message:</u>

HHXX
2906 00019 17001
22 /0040
33 /1251
55 10123 3152

Hydrological station 17001 on 29 January 1993 at 06h00 UTC. Stage 40 cm; discharge 1250 dm^3/s; Air Temperature 12.3 C; Maximum Temperature in the last 24 hours 15.2 C.

D.7) <u>BUFR code</u> (WMO code form FM 94-X BUFR):

<u>B</u>inary <u>U</u>niversal <u>F</u>orm for the <u>R</u>epresentation of meteorological data:

BUFR

Identification section

(Optional section)

Data description section

Data section

<u>7777</u>

BUFR is basically a self defining binary code for exchanging meteorological data. A BUFR "message" is a contiguous binary stream composed of 6 sections. Section 0 contains the coded characters "BUFR" and Section 5 the coded characters "7777" indicating the beginning and the end of a BUFR message. Section 1, Identification Section, contains information about the contents of the data, such as type of data, time of data, and whether or not the optional Section 2 is included in the message. Section 3 contains the description of the data that is represented in Section 4. Standard BUFR descriptors defined in BUFR tables B, C, and D are used for that purpose. Refer to the WMO Manual on Codes, Volume 1, International Codes, WMO N° 306, Part B - Binary codes - for details.

ANNEX IV: National Focal Points designated for drifting buoy programmes

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ANNEX VII: Argos Program Application Form

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ANNEX IX: Acronyms

ALACE   Autonomous Lagrangian Circulation Explorer
ATLAS   Autonomous Temperature Line Acquisition System
ATN   Advanced TIROS-N
CDA   Command and Data Acquisition
CLS   Collecte Localisation Satellite
CMM   Centre de Météorologie Marine
CMS   Centre de Meteorologie Spatiale (France)
CNES   Centre National d'Etudes Spatiales (France)
DBCP   Data Buoy Co-operation Panel
DCLS   Data Collection and Location System
DCS   Data Collection System
DCP   Data Collection Platform
DMN   Direction de la Meteorologie Nationale (France)
ESM   Equipment Support Module
EURONET   European Data Transmission Network
FGGE   First GARP Global Experiment
FRGPC   French GPC
GARP   Global Atmospheric Research Programme
GCOS   Global Climate Observing system
GOES   Geostationary Operational Environmental Satellite
GOOS   Global Ocean Observing System
GOS   Global Observing System (of WWW)
GPC   Argos Global Processing Centre
GTS   Global Telecommunication System
HRPT   High Resolution Picture Transmission
ID   Identification Code
IGOSS   Integrated Global Ocean Services System
IMP   Instrument Mounting Platform
IOC   Intergovernmental Oceanographic Commission
ITU   International Telecommunication Union
LUT   Local User Terminal
METEOSAT   European geostationary meteorological satellite
NASA   National Aeronautics and Space Administration (USA)
NDBC   National Data Buoy Center
NESDIS   National Environmental Satellite, Data, and Information Service (of
               NOAA, USA)
NOAA   National Oceanic and Atmospheric Administration (USA)
NWS   National Weather Service (of NOAA, USA)
OC   (Argos) Operations Committee
ODAS   Ocean Data Acquisition System
PO   Purchase Order
POES   Polar-orbiting Operational Environmental Satellites
PMEL   Pacific Marine Environmental Laboratory
PTT   Platform Transmitter Terminal

RAFOS	SOFAR (SOund Fixing And Ranging) spelled backwards since RAFOS is the reverse concept of SOFAR. With RAFOS floats, sound signals transmitted from moored buoy sites are received and the raw data transmitted through Argos for location computation.
RMS	Root Mean Square.
ROC	Representative Organization for a Country or group of Countries
RTH	Regional Telecommunication Hub
RSS	Reaction Support Structure
SOFAR	SOund Fixing And Ranging float. Signals are emitted from the float and then reveived at moored buoy sites for location computation.
SVP	(WOCE-TOGA) Surface Velocity Program
TAO	Tropical Atmosphere Ocean
TIP	Tiros Information Processor
TOGA	Tropical Ocean and Global Atmosphere program
TRANSPAC	(French Data Transmission Network)
TYMNET	(North American Data Transmission Network)
USGPC	United States GPC
VHF	Very High Frequency
WCRP	World Climate Research Programme
WMC	World Meteorological Centre
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WWW	World Weather Watch (of WMO)